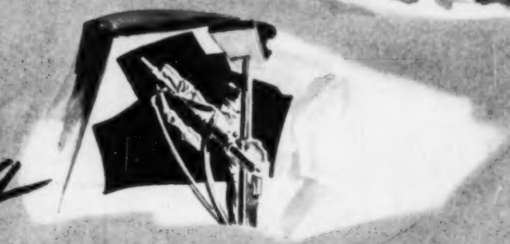
MINING ENGINEERING

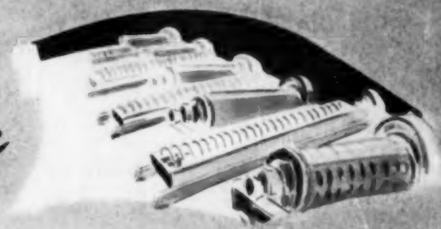
JANUARY 1950

Mineral Exploration

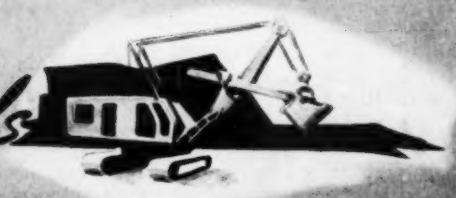
Metal Mining



Minerals Beneficiation



Industrial Minerals



Coal Mining and Preparation

Incorporating
MINING and METALLURGY
MINING TECHNOLOGY
COAL TECHNOLOGY

MINING ENGINEERING

VOL. 187 NO. 1 — JANUARY 1950

In This Issue

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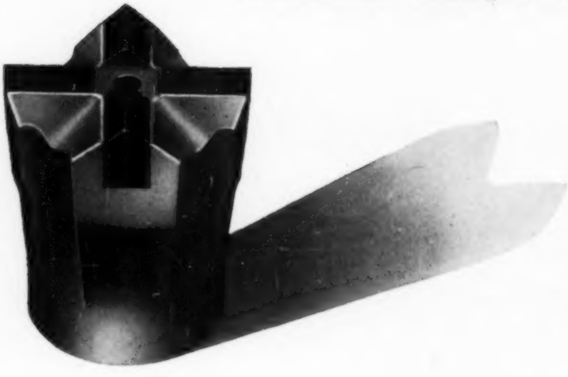
Carset Jackbits

Drill faster, 50% or more
Boost tonnage 20% or better
Finish more rounds per month!



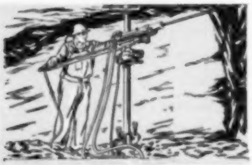
Now it has been Proved that you can do this, and much more, with the I-R CARSET JACKBIT

More than two years of actual field experience have given positive proof of what the CARSET JACKBIT can do – under all drilling conditions, in all kinds of rock. The results today are creating a complete revolution in rock-drilling performance and economy.

For here is a Carboloy-set bit that is repeatedly out-drilling and out-lasting a steel bit usage by 50-to-1, 100-to-1, and in many cases as much as 400-to-1! Uniformly high drilling speed is maintained for the full depth of the hole – without the progressive slackening in speed of quick-dulling steel bits. Bit changing is practically eliminated, longer steel changes can be used, and single-gauge holes can be drilled to any practical depth. This means more efficient drilling cycles, more rock or ore broken per shift – usually *20%* or more.

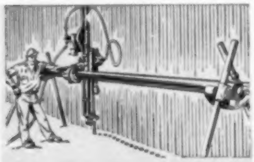
For the complete story on the CARSET JACKBIT, write today for your copy of our new 36-page, pocket-size catalog, Form 4091.

HERE ARE A FEW TYPICAL REPORTS ON CARSET PERFORMANCE

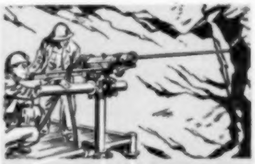


A MINING COMPANY, drilling in a very hard quartzite, reports that CARSET JACKBITS have so multiplied drilling speed that miners can now drill and blast on the same shift. With steel bits, blasting previously had to be done on the second shift. This customer has converted to CARSET JACKBITS 100%.

ON A LARGE DAM PROJECT, 2" CARSET JACKBITS were used with 4" Wagon drills operating in hard dense basalt. These bits drilled 24-ft. holes in 22 minutes, while steel bits previously used required 66 minutes for an 18-ft. hole (with 10 bit changes). Footage was increased from 120 to 261 ft. per shift.



IN A GRANITE QUARRY, CARSET JACKBITS have given such outstanding performance that steel bits are no longer used. Previously, with quick-dulling steel bits, the bit reconditioning shop had to be run two 8-hour shifts a day. This operation has now been almost eliminated.



A MINING COMPANY, in driving a 12 x 20 foot 97-hole heading in taconite, required an average of 49.8 hours to pull a 5-foot round. With CARSET JACKBITS they pulled 6½-foot rounds and cut this time to 18.5 hours. Accurate cost records showed a direct saving of $92.69 per foot of drift, or $602.48 per round.

CARSET JACKBIT

THE I-R SUPER-BIT

SET WITH CARBOLOY INSERTS

manufactured exclusively by

409-15

Ingersoll-Rand

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Personnel

Engineering Societies Personnel Service, Inc.
New York—8 West 40th St.
San Francisco—57 Post St.

Positions Open

Assistant Chief Engineer, 40-55. Must be graduate with at least ten to fifteen years' experience in smelting and refining of metal ores, and extensive background in plant improvement and expansion, material handling, furnace design and plant service facilities. Will act as a consultant on new construction layouts and cost estimates. $10,000-$12,000 a year. Location, Pennsylvania. Y-3023.

Junior Mining Engineer. Surveying and drafting in open pit department of a mining corporation in Arkansas. Possibility of being transferred to Jamaica, B.W.I. Starting salary, $3480 a year. Y-3033.

Geologist, not over 30, two to three years' experience in field geology on minerals. Considerable traveling. Must be willing to live as prospector in western states. $4200-$4800 a year. Headquarters, New York. Y-3055.

Asst. Electrical Supt., copper mine, Chile. Y-3066.

Mining Engineer, single preferred, experienced in supervising development, operation and maintenance of gold dredging equipment for exploration project in British Guiana. $4800-$5400 plus expenses. Y-2875-S.

General Manager to take charge of reduction and refining of ores. Must have considerable background and experience in production. Salary open. Location, northern New Jersey. Y-3014.

Mining Engineer, young, two to five years' experience, good knowledge of mechanized coal mining and knowledge of ore mining methods. Will function as assistant to executive in New York office and as liaision between mines and the office. Salary open. Location, New York Metropolitan Area. Y-1943.

Chief Engineer, 35-45, to take charge of all maintenance and mining operations for several widely scattered coal mines. Must have previous Eastern coal mining experience. Salary, $8000-$12,000 a year. Location, South. Y-2304.

Stratigrapher. Must have Ph.D., and be chiefly interested in Paleozoic stratigraphy and paleontology and capable of teaching sedimentation. Up to $4500 for nine months depending on experience. Location, Missouri. Y-2524.

Men Available

Measurement and Control Engineer, 44, married, registered, Harvard Business School training and practical sense, broad experience in process industries including milling and smelting, presently consultant to leading instrument firm, seeks consulting or full time work in cutting beneficiation costs or improve recovery through modern control methods. M-490-496-D-68-San Francisco.

Mining Geologist, M.S., Registered P.E. Ten years' experience all phases of underground mining operations; also property examination, valuation, geological investigations and technical reports. Available 30 days' notice. Willing to travel. M-491.

Mining Engineer, B.Sc., 38, married, no children. Twenty years' mining in gold, copper, tin alluvial, U. S. A., Canada, Panama, Peru, Malaya, England. Dredging hardrock open cut, quarry. Desires direction of exploration and development or management. M-492.

Mining Development Engineer, 38, B.S., married, 2 children. Twelve years' responsible experience, examining, engineering design, development by shaft and tunnel and operation of metal and non-metallic mines. Desires job requiring initiative, resourcefulness and executive qualities. M-493.

Mining Engineer, 35, university graduate, married, one child. Experienced mapping, geological exploration of metallic and non-metallic deposits, plant valuation, construction, mine accounting, flotation and ore dressing. Desires position in valuation work, operations, sales, purchasing, or connection with firm with mineral interests where background is valuable. Location immaterial. M-494.

Mill Man, 45, married, B.S., registered metallurgical engineer. Seventeen years' varied experience in flotation and cyanidation supervision, operation and research; surveying, assaying. Competent superintendent, testing engineer. Available for any job with reasonable opportunity permanent connection. Location preferred, U.S.A. or Mexico. M-497-475-E-6-San Francisco.

Mining Engineer and Geologist, 48, married, no children, E.M. degree 1926, Colorado School of Mines. Over 25 years' experience metal and non-metal mining, and economic and oil geology. Recently consulting work. Desire opportunity equal to professional qualifications. Available short notice. M-499-436-E-12-San Francisco.

The JOY *Line is* COMPLETE

Note, in the comparison below, how JOY EQUIPMENT stands out in its ability to take care of Metal Mine Requirements

	JOY	Company B	Company C	Company D	Company E	Company F	Company G	Company H
ROCK DRILLS								
Spaders	YES	YES	YES	YES	YES	NO	YES	YES
Busters	YES	YES	YES	YES	YES	NO	YES	YES
Jack Hammers	YES	YES	YES	YES	YES	NO	YES	YES
Stopers	YES	YES	YES	YES	YES	NO	YES	YES
Drifters	YES	YES	YES	YES	YES	NO	YES	YES
Drill Jibs	YES	YES	YES	YES	NO	NO	NO	YES
Drill Jumbo (Track)	YES	YES	NO	NO	NO	NO	NO	YES
Drill Jumbo (Trackless)	YES	NO	NO	NO	NO	NO	NO	NO
DRILL BITS								
Carbide Bits	YES	YES	NO	NO	NO	NO	NO	NO
Detachable Bits	NO	YES	NO	NO	NO	NO	NO	NO
Thro-Way Bits	YES	NO	NO	NO	NO	NO	NO	NO
HOISTS								
Single Drum Utility	YES	YES	YES	YES	NO	NO	NO	NO
Single and Two Drum Shaft	YES	NO	NO	NO	NO	NO	NO	NO
Two Drum to 15 HP	YES	YES	YES	NO	NO	NO	NO	NO
Two Drum to 125 HP	YES	YES	NO	NO	NO	NO	NO	NO
Three Drum to 15 HP	YES	YES	YES	NO	NO	NO	NO	NO
Three Drum to 125 HP	YES	YES	NO	NO	NO	NO	NO	NO
Sheaves	YES	NO	NO	NO	NO	NO	NO	NO
CORE DRILLS								
Blast Hole	YES	YES	NO	YES	NO	NO	NO	NO
Exploratory	YES	YES	NO	YES	NO	NO	NO	NO
COMPRESSORS								
Portable	YES	YES	YES	YES	YES	NO	NO	YES
Vertical—Air Cooled	YES	YES	YES	YES	YES	NO	NO	YES
Vertical—Water Cooled	YES	YES	YES	YES	YES	NO	NO	NO
Large Heavy Duty	YES	YES	YES	YES	YES	NO	NO	NO
LOADERS								
Scraper Slides	YES	YES	NO	NO	NO	NO	NO	NO
Mine Car Type	YES	NO	YES	NO	NO	YES	NO	NO
Trackless Loaders (Medium)	YES	NO	NO	NO	NO	YES	NO	NO
Trackless Loaders (Heavy)	YES	NO	NO	NO	NO	NO	NO	NO
MATERIAL HANDLING								
Shuttle Cars	YES	NO	NO	NO	NO	NO	NO	NO
Chain Conveyors	YES	NO	NO	NO	NO	NO	NO	NO
Shaker Conveyors	YES	NO	NO	NO	NO	NO	NO	NO
Belt Conveyors	YES	NO	NO	NO	NO	NO	NO	NO
MINE VENTILATION								
Portable Blowers, Electric	YES	NO	NO	NO	NO	NO	NO	NO
Portable Blowers, Air	YES	NO	NO	NO	NO	NO	NO	NO
Large Mine Fans	YES	NO	NO	NO	NO	NO	NO	NO

WRITE FOR BULLETINS, OR *Consult a Joy Engineer*

WBD M2572

JOY MANUFACTURING COMPANY

GENERAL OFFICES: HENRY W. OLIVER BUILDING · PITTSBURGH 22, PA.

IN CANADA: JOY MANUFACTURING COMPANY (CANADA) LIMITED, GALT, ONTARIO

Manufacturer's News

Locomotives. A new, 16-page bulletin, GEA-3810A, describing the 80-ton diesel-electric locomotive for industrial switching, has been released by the General Electric Co., Schenectady, New York.

Earth-moving Equipment. "Euclid Loader for High Speed Loading of Large Hauling Units," is the title of a new 24-page book issued by The Euclid Road Machinery Co., Cleveland, Ohio. It contains operating views showing the loader at work on various jobs in this country and abroad. Euclid loaders have established excellent production records for bigger yardages at lower costs in many countries of the world on practically every kind of earth-moving job.

Rotary Positive Blowers. Bulletin 21-B-37, covers the smaller size Type AF rotary positive blowers for pressure or suction service, manufactured by Roots-Connersville Blower Corp. This 8-page bulletin covers the construction features and operating advantages of rotary positive blowers, which are built in eighteen standard sizes.

Ball and Roller Bearings. A new 112-page detailed catalogue and engineering data book, covering Link-Belt's complete line of ball and roller bearings, has been released. It points out important construction features and gives list prices, weights, load ratings, and all the necessary dimensions for the various standard models available. Book No. 2550, now available from the Company on request.

Transmission belting. The U. S. Rubber Co. has published a new 28-page catalogue giving detailed design, engineering, and performance data for its line of transmission belting.

Classifiers. A new and distinctly different Dorr Classifier is described in Bulletin No. 2281, "Dorr Type H Classifier." The result of four years of development and testing, and incorporating an entirely new head motor design and rake path, the Type H supplants the Type F on all but the light duty Model FR and laboratory units.

Equipment

The Joy Manufacturing Co., Pittsburgh, offers a new diesel-electric shuttle car. This model, pictured here, is said to be exceptionally powerful and can operate on steeper grades than either battery or cable-reel cars. It carries its own power source and is flexible in operation. The fuel capacity provides rated power throughout the full shift. The 60-E-11 is powered by a single diesel-generator set. The engine manufacturer and Joy engineers havv produced a lightweight, compact engine, especially suited for shuttle car use.

Safety Lamp. A junior size flame safety lamp, lighter and smaller than standard models, has been announced by Mine Safety Appliances Co. Improved ventilation, standard height chimney and standard ignitor account for the cool burning of this lamp. Seventy percent of the Junior Lamp parts are interchangeable with those of standard model lamps.

Pneumatic Idlers. The Goodyear Tire & Rubber Co. first introduced pneumatic idlers in 1938, and they consisted of regular industrial tires, small in cross-section and large in overall diameter. The company has now redesigned the impact-cushioning pneumatic idler for conveyor belts. The new idler uses airplane tires which will absorb several times the shock of the type formerly used. Goodyear does not intend to manufacture the idler, but it was developed as a service to the conveyor belt industry and its customers.

Bruning Drafter. The Charles Bruning Co. of Chicago has introduced a new model drafter with exclusive "Equipose" mechanism for overcoming gravity.

Full-voltage Starter. A new wall-mounted, full-voltage starter, Type 371, especially adaptable for use in industries in which corrosive vapors or combustible dust-laden atmospheres are present has been built by Allis-Chalmers Mfg. Co. This new starter has its entire mechanism immersed in oil and sealed from the atmosphere. It is weather-proof and can be used for outdoor installations.

Conveyor Belts. Nylon in combination with cotton is fast becoming the favored material for the construction of heavy duty conveyor belts used in copper, iron ore, and coal mines. The number of cotton-nylon belt installations is steadily increasing. Recently a 2000-ft. cotton-nylon belt was installed in southern Arizona for handling copper ore. At a coal mine near Scranton, Pa., a 5300-ft. cotton-nylon belt is carrying 300 tons of coal per hour and results in a saving of 50¢ per ton of coal mined.

Dust Mask. The new M.S.A. All-Vison Dust Mask provides complete facial and respiratory protection against dusts. Fitted with a light-weight, flexible all-rubber face-piece the mask conforms snugly to the contours of the face, forming a gas-tight seal. A large-area, inexpensive, throw-away filter which can be quickly replaced affords the maximum in low breathing resistance.

Sinker Drill. The Gardner-Denver Co., Quincy, Ill., has announced a new 45-lb. class sinker of advanced design known as the S48. It is said to have superior drilling, rotating, and hole cleaning characteristics that make it suitable for use with tungsten carbide bits, and is designed for either wet or dry drilling.

The Smith Engineering Works of Milwaukee, Wis., has announced two new models of the Telsmith Gyrasphere Crusher—the Style S Standard Gyrasphere and the Style FC Fine Crushing Gyrasphere. They include many new improvements, incorporated after several years of testing in actual service, which give greater capacity, a more uniform cubical product, and a lower crushing cost per ton. In the new Style S Standard Gyrasphere, larger roller-thrust bearings are now located at the top of the eccentric and transmit crushing pressures from the bottom of the head directly into the main frame. A longer crushing stroke gives greater capacity. The eccentric bearings have more bearing area in the upper zone of greatest crushing pressures. Longer springs are used, to pass larger pieces of tramp iron. The main drive gear is now located at the bottom of the eccentric instead of at the top, assuring more perfect and

more permanent alignment of gears and longer life for these parts. The new model is more accessible for maintenance purposes. The Style S Standard Gyrasphere is available in the 24, 36 and 48 in. sizes with either coarse or medium bowl. The new Style FC Fine Crushing Gyrasphere has the same structural improvements as the Style S, plus several additional fine crushing features. It comes equipped with a new feed distributor, for even feeding and a more uniform product. It has more springs to handle greater crushing pressures. The Style FC has a different shape of mantle and concave with a longer parallel crushing zone to give a finer product. New Gun-Lock type mantle and concave holding devices are automatically self-tightening and make these parts easier to change. The Style FC Fine Crushing Gyrasphere Crusher also is available in the 24, 36 and 48 in. sizes with either medium or fine bowls. A new catalog #274 describing and illustrating these two new Telsmith Gyrasphere Crushers may be secured by writing Smith Engineering Works, Milwaukee 12.

Another shovel having **"Magnetorque"** electric swing has been added to the **P&H** line of excavators. This machine, Model 955-A, has a capacity of 2½-yd as a shovel and 3-yd as a dragline. "Magnetorque" swing was introduced a few years ago in the larger P&H model 1055 (3 to 4-yd. excavator) and has been so successful that it has been applied to this slightly smaller machine. Features of this electro-magnetic type swing mechanism are: elimination of all friction on swing and propel motions; smoother, more responsive swinging; more accurate and faster starts and stops; and a virtual end of maintenance costs. "Magnetorque" units, according to the manufacturer, last the life of the machine. Daily output is said to be increased, due to the elimination of waste motions and lowered maintenance time. Like all shovels in this line, the Model 955-A is of all-welded construction of rolled alloy steels and has simplified heavy duty hydraulic control of the proved automotive type. It is easily converted for four types of service: shovel, dragline, crane and clamshell. This excavator is designed with clearances which permit shipment via railroad flatcar, completely assembled. Complete information on this 2½-yd shovel may be obtained by writing Harnischfeger Corporation, Large Excavator Division, 4400 West National Avenue, Milwaukee 14, Wis.

Pumps. A new, high efficiency, long life, solids-handling pump manufactured by Thomas Foundries, Inc., Birmingham, Ala., is creating interest in the dredging, mining, and sand and gravel fields. Unusually long life records have been set by this pump because of its unusual design and because it is made of Thomas Ni-Hard, one of the hardest and most abrasion resistant products of the foundry industry.

Promotions • News Notes

Fred O. Benson has been appointed sales representative for the **Flexible Steel Lacing Co.**, Chicago, manufacturers of belt fasteners and belt cutters. He succeeds **Sam Baker** who retired last year after 31 years' service.

Chain Belt Co. of Milwaukee has announced the election of **W. J. Sparling** as vice-president and manager of the Chain and Transmission Division.

Tench G. Swartz has been appointed Arizona field engineer by the **Denver Equipment Co.**, manufacturers of mineral recovery equipment. One of Mr. Swartz' chief responsibilities will be to work with other mining engineers to maintain or improve mineral recovery while reducing operating costs.

Fairbanks, Morse & Co. has appointed **Frank M. Mason, Jr.**, Director of Engineering. He joined the company in 1922 and for several years has been manager of the Research Division in charge of all research, developments and patents.

Templeton, Kenly & Co., manufacturer of Simplex jacks, has appointed **Mark C. Simpson** as Pennsylvania Division Sales Manager.

After 40 years of heavy-duty service with the Dolese & Shepard Co. quarry, LaGrange, Ill., 30 **General Electric motors**, ranging from five to 250 horsepower, are still operating efficiently, according to G. E. The motors have been used steadily with a minimum of repair and servicing, while undergoing severe quarry loads and working conditions.

The New York office of the **Eimco Corporation** is now at 51-52 South St. This company, manufacturers of underground rock loading machines, has expanded laboratory facilities for test service. It also carries a complete stock of repair parts for Eimco products.

A big, colorful relief map of Venezuela, in lightweight plastic, has been produced by **Aero Service Corp.** of Philadelphia for the Creole Petroleum Corp. One thousand of these maps will be distributed in Venezuela by the oil company as part of its broad public relations program. Aero has been engaged in aerial mapping since 1919, working all over the world.

The Dorr Company has acquired rights to the metallurgical jigs and sewage aerators of the Pan-American Engineering Co. The design, production, and marketing of this equipment will be taken over by The Dorr Co. W. G. Moore, formerly design engineer for Pan-American will become a member of the Dorr engineering department in New York.

Newly designed mantrip cars for Jones & Laughlin Steel Corporations' Vesta Mines 4 and 5 and Shannopin Mines in western Pennsylvania can be quickly transformed into ambulances for emergency work. A special first aid outfit developed by the **Mine Safety Appliances Co.** is stored in each car. This steel first aid case, containing folding stretcher, splints, blankets and other equipment, is designed to resist dampness and dust.

— Authors in This Issue —

S. J. Swainson

S. J. Swainson, author of the minerals beneficiation review, heads the mineral dressing laboratory for the American Cyanamid Co. Research Laboratories in Stamford, Conn., having been with that firm since 1926. An AIME member and chairman of the Minerals Beneficiation Division, he holds B.S. and M.S. degrees from the Univ. of North Dakota and Univ. of Utah, respectively. He has presented several other papers before the AIME. Mr. Swainson enjoys fishing and golf in his spare time . . . **R. E. Byler,** a contributor to Mr. Swainson's minerals beneficiation review, has been associated with The Merrill Co. for fifteen years and is at present vice president. Mr. Byler has a B.S. from the Univ. of California, and has spent 25 years in plant design and operation, and development of beneficiation processes and equipment in Mexico, western United States, and Canada. An AIME member, he serves as regional vice chairman of the Minerals Beneficiation Division. . . . **Harlowe Hardinge,** who also worked with Mr. Swainson on the beneficiation review, is now president of the Hardinge Co. in York, Pa., having been with that firm since 1919. Prior to 1919 he served as a captain in the AEF during World War I, and worked at various Canadian mines. Born in Denver, he attended the Tome School in Port Deposit, Md., and then took an M.E. from Cornell Univ. An AIME member and chairman of the Crushing and Grinding Committee, MBD, he has presented several papers before the Institute. For relaxation, he turns to the links, the streams, and the woods. . . . **G. Carman Ridland,** (p. 98) lives in Denver where he is a consulting engineer. Born in New Westminster, B.C., he attended the Univ. of British Columbia and Princeton Univ., receiving B.A. Sc., A.M., and Ph.D. degrees. Dr. Ridland has been resident geologist for the Bear Exploration and Radium Co., Yellowknife, NWT; research engineer, Johns-Manville Corp., Manville, N. J.; and geological engineer, Canadian Radium and Uranium Corp., New York City. He has presented one other paper before the AIME. . . . **S. D. Michaelson,** chief engineer of the Tennessee Coal, Iron and Railroad Co.'s. coal mining department, and another contributor to the beneficiation review, has been a field engineer for Bethlehem Steel, an ore processing engineer and director of Basic Industries Research Laboratories for the Allis-Chalmers Mfg. Co., and a Lt. Colonel with Army ordnance during the last war. He has a B.S. in mining engineering from Lehigh Univ. Mr. Michaelson, an AIME member, resides in Birmingham, Ala., where he enjoys trout fishing, bird hunting, and mountain climbing. He has presented numerous other papers on crushing, grinding, and concentration before the Institute. . . . **M. F. Morgan** of Cleveland is now an ore beneficiation consultant with Arthur G. McKee and Co., having been a superintendent for both Bethlehem and Republic Steel. Born in Chicago, he attended Rayen High School in Youngstown, and then studied at Newberry College. Mr. Morgan heads the Committee on Pyrolysis and Agglomeration for the MBD, and in this capacity contributed to our beneficiation review. . . . **E. J. Roberts,** another contributor to the minerals beneficiation review, was born in Kalispell, Mont., and received B.S. and Ph.D. degrees from Yale's Sheffield and Graduate Schools, respectively. He was also an instructor at Yale for three years. Dr. Roberts has been research director for the Dorr Co., Westport, Conn., since 1941, having been with that company since 1928. A member of AIME and chairman of the MBD Committee on Solids-Fluids Separation, he has contributed several papers before the Institute. Dr. Roberts' hobbies are mapping and maps, fixing things, and photography. . . . **Sherwin F. Kelly,** author of the geophysics review, established and heads Geophysical Explorations, Ltd., in Canada, and Sherwin F. Kelly Geophysical Services, Inc., in the U. S. Born in Las Cruces, N. Mex., he received his B.S. degree in mining engineering from the Univ. of Kansas. A member of the Institute, Mr. Kelly was chairman of the Geophysics Committee, of which he is currently secretary, for several years and also chairman of the Geophysics Education Committee. He contributed many papers to AIME publications, and has also prepared numerous annual reviews. His pleasures consist of "photography and stamp collecting, but mainly geophysics." . . . **R. E. Zimmerman,** chief of the coal preparation division at Penn State College (where he received his B.S. and E.M. degrees) and coal preparation consultant, is one of the contributors to the coal review. Considered an expert in the preparation and utilization of coal with many years' experience in research, development, and operation of coke and coal preparation plants in the United States and abroad, he has presented many articles on these subjects before the AIME, of which he is a member. Mr. Zimmerman enjoys fishing, golf, and traveling to faraway places of the world. . . .

R. E. Byler

H. Hardinge

G. C. Ridland

E. J. Roberts

S. F. Kelly

R.E.Zimmerman

Authors


Ferid Kromer

Ferid Kromer, (p. 108) is general manager of Bastas Türk Maadin, Ltd., Istanbul, Turkey. He was educated at the Ecole Nationale Superieure des Mines, France, and Columbia Univ., receiving the degrees of B.S. and E.M., and took graduate engineering courses at Allis-Chalmers Mfg. Co., Milwaukee. He is an Institute member, and this is the second TP he has contributed to AIME literature. Mountain climbing in Anatolia, and fishing in the Bosphorus rate as his chief pleasures. . . . **T. M. Morris,** (p. 91), having received his B.S. and M.S. (in mineral dressing) from Columbia Univ., is at present attending the Missouri School of Mines where he expects to receive his Ph.D. in June. Mr. Morris was a Navy Lieutenant (j.g.) during the war and had sea duty in the north Pacific. Prior to his stint in the service, he was assistant research engineer for Anaconda Copper Mining Co. In his spare time, he enjoys hiking, fishing, golf, and painting. . . . **John B. Murdock,** Lt. Colonel during the war and now president of the Perlite Corp. in Phoenix, Ariz., is co-author of the TP on p. 111. Mr. Murdock is a member of the Institute, and this is the first AIME paper that he has authored. Prior to his present position, he was a partner in the firm of Murdock & Bassler. Born in Tempe, Ariz., he attended the Phoenix Union High School, and received his B.S. degree from Mass. Inst. of Tech. . . . **S. G. Lasky,** who is a member of the AIME, presents his annual review of mining geology. Since 1931, he has been on the staff of the U. S. Geological Survey, in Washington, in various responsible positions, and in 1948 was made chief of the newly created mineral resources section. Mr. Lasky was born in Denver and took his E.M. from the Colorado School of Mines (where he was also teaching fellow in chemistry) and his M.S. from Yale. Before his affiliation with the USGS, Mr. Lasky was employed by the New York and Honduras Rosario Mining Co., Kennecott Copper Corp., and New Mexico Bureau of Mines and Mineral Resources. The AIME published his first paper in 1923, and since that time Mr. Lasky has contributed many technical articles to the Institute publications. . . . **Grover J. Holt** is a mining engineer and now with the Cleveland-Cliffs Iron Mining Co., Ishpeming, Mich. After graduating from the Univ. of North Dakota with a B.S. in mining he went to work as an engineer with the Basin Metals Mining Co. in Ouray, Colo., then served as a Lieutenant with the Army engineers during World War I. Later he became chief engineer for Butler Bros. in St. Paul. Mr. Holt is a native of Northwood, N. D. His AIME membership dates from 1941.


W. C. Williamson


G. J. Holt

W. C. Williamson was born in Ishpeming, Mich., and attended the Michigan College of Mines and Tech., receiving B.S. and E.M. degrees. He taught mathematics, general science, and physics at Suomi College, Hancock, Mich. Starting his affiliation with Anaconda Copper Mining Co., at Butte, as a mucker in 1923, Mr. Williamson advanced in 1934 to his present position of assistant ventilation engineer. He is an AIME member, and enjoys fishing and prospecting when he is not on the job. . . . **A. J. May** presents his first TP for the AIME on p. 81. He attended the Episcopal High School of Virginia, and received his E.M. degree from the Colorado School of Mines. When not on the job as shaft superintendent for the American Smelting and Refining Co., at Vanadium, N. Mex., Mr. May likes to fish and hunt. Among the jobs he has held are those of mine superintendent of Big Bell Mines, manager of South Mountain Mine, and mine superintendent of Buchans Mining Co. . . . **Lauren A. Wright,** AIME member, has been associate geologist for the California Division of Mines, in San Francisco since 1947. His TP entitled "California Talcs" appears on p. 122.

Correction


S. A. Easton

Stanly A. Easton, (right) president of the Bunker Hill & Sullivan Mining & Concentrating Co., was wrongly identified on p. 41 of the December issue as president of the American Mining Congress. Howard I. Young is president of A.M.C., and news of his appointment appears on p. 143 of this issue.


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LOGGING
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PETROLEUM
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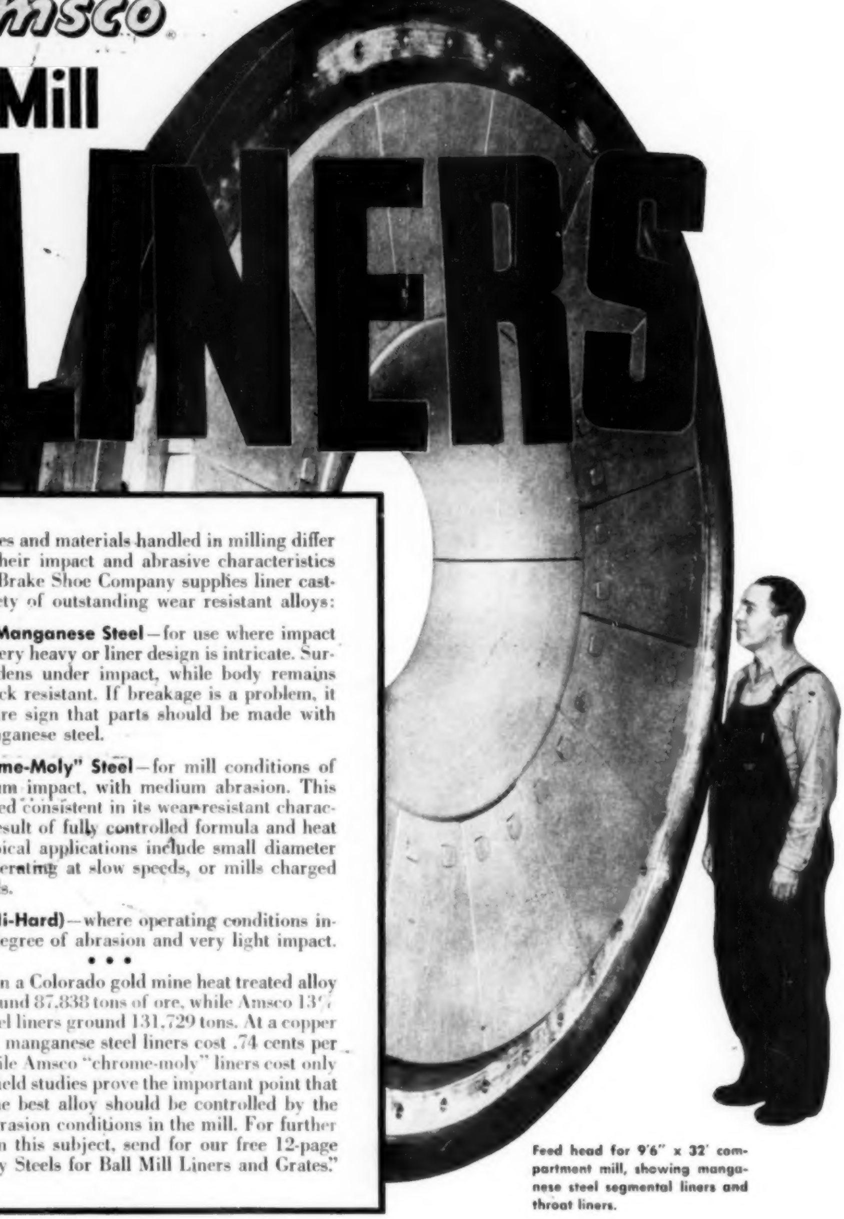
Amsco

Ball Mill LINERS



Because the ores and materials handled in milling differ so widely in their impact and abrasive characteristics . . . American Brake Shoe Company supplies liner castings in a variety of outstanding wear resistant alloys:

Amsco 13% Manganese Steel—for use where impact is medium to very heavy or liner design is intricate. Surface work-hardens under impact, while body remains tough and shock resistant. If breakage is a problem, it is almost a sure sign that parts should be made with austenitic manganese steel.

Amsco "Chrome-Moly" Steel—for mill conditions of light to medium impact, with medium abrasion. This alloy has proved consistent in its wear-resistant characteristics, the result of fully controlled formula and heat treatment. Typical applications include small diameter mills, mills operating at slow speeds, or mills charged with small balls.

ABK Metal (Ni-Hard)—where operating conditions involve a high degree of abrasion and very light impact.

• • •

For example, in a Colorado gold mine heat treated alloy steel liners ground 87,838 tons of ore, while Amsco 13% manganese steel liners ground 131,729 tons. At a copper mine standard manganese steel liners cost .74 cents per ton milled, while Amsco "chrome-moly" liners cost only .68 cents. All field studies prove the important point that selection of the best alloy should be controlled by the impact and abrasion conditions in the mill. For further information on this subject, send for our free 12-page booklet, "Alloy Steels for Ball Mill Liners and Grates."

Feed head for 9′6″ x 32′ compartment mill, showing manganese steel segmental liners and throat liners.

AMERICAN Brake Shoe COMPANY

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Letters to the Editor

Report from Japan

I read with great interest the article "Japan's Mineral Industry", by John J. Collins. (*M.E., July 1949.*) It is a pleasure to report that coal production in Japan has now reached an average monthly production of more than three million metric tons, an all-time high since the termination of hostilities.

The coke program is progressing nicely under the able guidance of Mr. Caleb Davies, Jr., on loan to the natural resources section from the Disco Corp. Incidentally, this program was started by Dr. Frank Reed of the Illinois Geological Survey, and has the chief aim of making Japan self-sufficient in metallurgical coke and the elimination of the necessity for continued imports of low-volatile American coals. Although all of the Japanese coal is high-volatile bituminous, with the exception of a very small amount of semi-anthracite in Kyushu and Western Honshu, coal from certain mines has been proved to be valuable in making coalite (char) by low temperature carbonization. This is blended in various proportions with other weakly to moderate caking coals to make a good grade of blast furnace coke.

Belated congratulations on the new publications set-up. The articles on coal appearing in **Mining Engineering** have been very helpful in discussing preparation problems with the Japanese.

Charles S. Merriam
Chief, Solid Fuels Branch, Natural Resources Section, SCAP
Tokyo, Japan.

The U. N. Conference

In regard to the October issue of Mining Engineering and its editorial, I can agree with you that there is much to be done before any basis of action could be arrived at. . . . Their only objective for a meeting such as the U.N. Scientific Conference for the Conservation and Utilization of Resources is one of simply having scientific representatives in this country and other countries become familiar with one another's resources and problems.

As a co-author and delegate to the Conference [I note] an unmistakable envy of our country's resources and the great advantage which we have through our higher standards of living. There was manifest in at least one paper a fear of the U.S. using up the world's resources before the other countries could get around to enjoying their share . . . . and from the point of view of some of these countries, there was an unmistakable trend and thought that perhaps the U.S. should be controlled in its greater scale of exploitation of world resources. [But] many countries whose ideologies are at variance with the enterprise system seemed to refuse to recognize that the wealth of the U.S.A. is a result of free enterprise and a freer, less heavily taxed people.

Discussion showed a considerable concern over the fact that we are using up the world's resources at a great rate, and that perhaps very little will remain for future generations.

I don't hold with this view. Going back a few ages, man knew nothing about the available natural resources in the earth. Then there was a period in which we thought elements were fire, earth, water and air. After that we learned about a table of 92 elements. More recently we have learned about molecules and about atom structures. Would it not be too unreasonable, on the basis of such progress, to assume that our horizons are becoming even broader, and hence our resources will in time be less and less exhaustible? I believe that this generation is *expanding* the world's resources and giving to generations to follow better and better standards of living.

T. M. Ware, Chief Engineer,
International Minerals & Chemical Corp.

Federal aid?—No, thanks!

According to the **Denver Post** the Colorado mining industry has "demanded federal aid to keep itself alive." I will be among the sufferers if it dies. I believe, however, that all members of the mining industry should look critically at a proposal for federal aid. If the government finances exploration it is usurping a primary function of capitalism—risk taking. But would it not be better to bring pressure to bear, from every possible angle, to have taxes reduced to give an incentive to private industry to take the risk? Some special relief from taxation might be arranged for the early production from any new mining development. If an investor were allowed to recover his investment, then taxes could be raised gradually to normal levels.

Let us look squarely at the fact that any direct relief can come from one source only—**higher taxes.** I may be wrong, but to my mind there is nothing like increasing taxes to kill the goose (private industry) that laid the golden egg (the present standard of living enjoyed by 150 million Americans).

Hedley S. Fowler
Blubber Bay, Canada

Information, Please

Victor H. Verity, mining engineer and lawyer, of 613 Valley National Bldg., Tucson, Ariz., spends many an interesting spare hour collecting old miners' lamps, but the one pictured here has him stumped. He acquired it recently from J. L. Splane, of Moreno, Sonora, Mexico, who had in turn acquired it from his father Frank, who had received it from Lycurgus Lindsey, formerly of Nogales, Arizona.

Said to have burned fish oil, and to have been used in the vicinity of California circa 1898, the lamp remains a mystery to Mr. Verity. Can one of our readers supply him with some accurate facts about where these lamps were made and used?

* Kennecott Copper Corp. gets Charles R. Cox as president on Jan. 1. Mr. Cox is resigning his position as president of Carnegie-Illinois to take the new post with Kennecott, left vacant by the death of Mr. Stannard in September.

* The ECA signed a contract in December to advance $3,600,000 to Newmont Mining Corp. to aid development of lead and zinc mines in French Morocco. The funds are to be repaid in lead and zinc for the United States' stockpile over a period of seven years. The mines are owned by the Societe des Mines de Zellidja, with which organization Newmont is associated.

* Under the direction of John M. Brooks, Jr., general manager, the Matahambra mine in Cuba, will probably produce sufficient tonnage to make 4 million lb of copper per month during 1950. The grade is presently running between 7 and 10 pct.

* S. H. Ash reports that the fatality rate per million man-hr for the anthracite industry for 1949, through November, is 0.78. This is 15 pct better than that achieved during 1948, which was the lowest fatal injury rate in coal mining history. The first full year on record without a major disaster was recorded in 1949 (p. 34).

* The Atomic Energy Commission has authorized the production of 200 lb of uranium metal for use under AEC license in non-Commission research projects.

* A national survey of projected 1950 purchases of new machine tools, machine tool accessories, materials handling equipment, etc., just completed by the American Society of Tool Engineers reveals that, of the companies reporting, 80 pct state that they plan to buy either more equipment or the same amount as in 1948.

* Armour Research Foundation is conducting investigations for the use of clay and shale deposits to make lightweight aggregates. The material is heated until it expands and forms material suitable for mixing with cement which it is hoped will be lighter, stronger, have better insulating qualities and will lower the cost of concrete.

* In the first six months of 1949 the bituminous coal miners' average hourly earnings were $1.94, as compared with $1.39, national average for all manufacturing. Average annual earnings of full-time employees in the bituminous coal mines in 1948 were $3387 as compared with $2809 for all industry.

* LaSalle Business Bulletin reports: "year ends on a rising trend in industry and trade...nearly record-breaking demand from almost all sources keeps business high... most indicators but little below postwar peak...forces keeping activity high are still powerful--changes in general business conditions likely to be slow and moderate."

* Office of Internal Trade of the Commerce Department requests that technical data significant to the national security which is to be sent outside of the United States be submitted to it for an official opinion on the desirability of transmitting such information. This voluntary compliance program is part of our national security control.

* Blast furnace slag reduced to 12 to 16 mesh is being used for sanding track at the Mont Coal mines of Armco. The slag replaces silica sand which caused silicosis. It has proved so effective and cheap that tests are being made to use the slag for rock dusting.

A Tribute to the Mining Engineer

A SELF-RESPECTING miner doesn't wash the cuttin's off his hard hat until he quits his job but, on the other hand, he keeps his lamp clean and a "spot" focus on the work at hand; the former habit is a matter of pride and the latter serves for efficient operation. During 1949, the mining engineer got all the "wet raises"—for the problem of cutting costs to meet the drop of metal prices and keeping research work up to schedule when strikes tied up his work were his headaches. We note, not without admiration, that he hasn't washed the muck off his hat in token of surrender but, on the contrary, his light shines bright on the job to be done as can be seen in the following pages.

Few people have any conception of how much ore and rock have to be mined and how much sorting it takes to cull a pound of copper from a 1% ore body. These people would be even more startled to picture the problems faced by the engineer in mining and extracting, profitably, .2 oz of gold from a ton of ore as is done at some of our lode mines.

Strikers have sometimes kept our researchers from their pilot plants and research laboratories, but the end of the year shows progress in making ore out of taconite and ferruginous sandstone, with a pilot plant in operation at Aurora, Minn., and plans for one near Birmingham. Unfortunately, it looks as though the mining engineer will have to make John Doe secure in mineral resources in spite of himself.

Coal for steel, power, and to warm our homes is still economically possible, in spite of Mr. Lewis, through development of mechanized tools for mining. During the year, the use of continuous mining machines has extended, transport systems are being adopted to keep the ore flowing from the face to the tune of 40 tons per man-shift. Experiments in the gasification of coal are going forward in several places and may eventually extend our fuel reserves by the addition of coal seams now too lean for mining. Liquid fuel from coal, oil shale, or natural gas will become economic when oil consumption exceeds our supply; but, at less than 30 cents a ton direct cost for mining oil shale, the engineer is almost making it competitive under present market conditions.

In this age of specialists, the mining engineer is still holding his own as a broad-gauge man. As a matter of fact, he is emerging from a stage of semi-specialization as a coal, nonmetallics, or metal mining man to the realization that, with mechanization, mining is fundamentally materials handling whether it is fluorspar, coal, or copper ore. From the coal business come rubber-tired mechanical loaders to the iron mines of Birmingham. Shuttle cars are also finding application in the lead mines of the Tri-State. Open-pit methods are universal. Belt conveyors, trucks, Diesels, and mobile, jumbo-mounted drills are finding application in all types of mining.

In preparation, such methods as flotation, heavy density, electrical, and centrifugal are finding application in coal, nonmetallics, and metals. These concepts have been recognized by the mining engineer who has kept himself informed and has been quick to seize a method, machine, or a process from another operation and, with ingenuity, applied it to his problems.

This, our Annual Review issue, is written by mining engineers. In gathering these separate articles under one cover for publication, we think of it as a tribute to the tireless energy and skill of these men. They get little of the publicity accorded physicists, medical men, labor leaders, or company executives, but they supply raw materials without which industry would die.

It's Everyone's Business

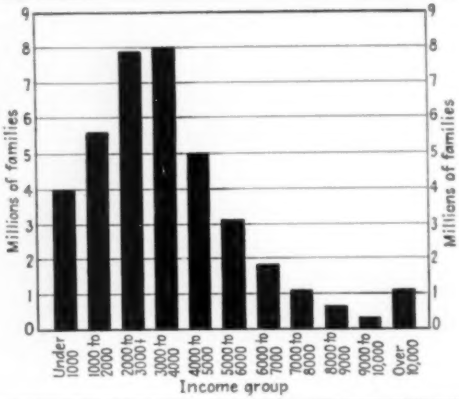
DEC. 20—The spirit of Christmas and good will toward men has managed a few brief appearances on the front pages, welcome relief from man's usual ill-will toward man. A couple politicos did their best to brighten the scene by well-publicized romances. There was a general exodus to Florida to patch up nervous systems, and even the UNO quieted down as Mr. Vyshinsky departed for home via Eastern Germany. Before going he opened up a preliminary bombardment for the worldwide "communist peace offensive," and it is now the duty of the 600 million (according to the Cominform) ideological converts to press home the attack.

In Washington, Mr. Lilienthal resigned as Chairman of the Atomic Energy Commission and demonstrated again the difficulty of government to retain the services of capable men. The President has yet to appoint another victim—possibly someone nicely noncontroversial and timid. So might the critics be appeased, but it would bode ill for the rapid exploitation of peaceful uses of atomic energy, the relaxation of excessive secrecy, wider sharing of developmental work with friendly nations and possible revision of the Acheson-Lilienthal proposals for international control of the atomic bomb.

Mr. Clark Gifford, one of the President's closest aids, also resigned, he to go after the rewards of private work and better take care of three children. It was Mr. Gifford who in the dark summer of 1948 pumped conviction into the President that the Fair Deal could win and it was he who wrote the speeches showing the President to be a homespun humanitarian. And over in the Interior Department, Mr. Krug (who expected a Dewey victory) dropped off without fanfare. Mr. Oscar Chapman got the job, a victory for merit and devotion. Mr. Chapman is sincere and able. Furthermore he campaigned vigorously for Mr. Truman.

Along the pension front the Bell Telephone System has ordered an immediate increase in monthly payments from $50 to $100, less Federal Security payments. The union, however, is very annoyed at such cutting of the ground from under one of their main claims and has proposed bringing charges of unfair labor practices against the System for making the increase without proper consultation and collective bargaining. With steel, coal and telephone well pensioned, and a foothold secured in Detroit, the growing campaign to pry open the Federal treasury to increase old-age pensions (now at $26 monthly) has won some formidable allies in private industry. Even Senator Taft, who calls the welfare state the "farewell state," inquires as to why some workers should have superior protection.

In mid-November some 59,518,000 Americans were employed, an unknown number were on short shifts and unemployment had dropped to 3,490,000, a goodly decline from the July peak of 4,000,000 unemployed which had resulted in such fretful concern in many quarters. In mid-July there were 35 areas in 14 states with 12 pct or more of the working population hunting jobs. However, by the end of September some $80 million in Federal procurement and construction contracts and loans had been funneled into these depressed areas, and there has resulted considerable alleviation of distress. To the generally improved business conditions throughout the country, however, goes some of the credit. The country still has a goodly number of families on the lower rungs of the economic ladder (see graph), and these groups are now the subject of



several studies of the factors contributing to low income and the circumstances in which low-income families live, in cities and farms.

Among the base metals copper alone has remained firm during recent weeks at 18½¢ per lb. The demand which comes mainly from the building industry is strong, and is not expected to slacken in the immediate future. Copper consumption is currently estimated as being well above current production plus imports, but stocks were built up fairly well during the first half of the year. Contrary to expectations the ending of the steel strike did not bolster the zinc price and quotations have fallen off to 9¾¢ per lb. Lead broke on Nov. 25 to 12¢ a lb, the level in effect last June. Demand for lead has tended to weaken within recent months although Europe is still shipping supplies in search of dollars. In tin, prices have persisted on the downward side to today's quotation of 78.25¢. Turnover has not been large. Tin activity will not begin to look like a real market until more supplies are available from competitive sources in the Far East. But already weakness in the tin price has led to a special meeting of certain member countries of the Tin Study Group in The Hague to consider

reestablishment of the prewar buffer-stock scheme.

Now that Paul Hoffman has laid down the dictum that countries in the Marshall area must liberalize trade relations to stimulate recovery, many producers are taking fright and exploring trick ideas to protect their industries from the searching winds of foreign competition. There are signs that the prewar coke cartel is being revived, similar moves are underway in scrap steel and chemicals, and steel and coal may join the list. Certain European steel producers are toying with the idea of transplanting the American basing point mechanism from American to European soil. The French have also come up with the scheme whereby high-cost producers would sell out to their more efficient competitors. The NAM has already started to prod Mr. Hoffman's organization, and it is unlikely that ECA will remain passive to all these maneuverings for long.

All over Europe and Asia individuals bob around uneasily on the surface ripples while ponderous political and economic forces clash far in the deep. In Western Germany the opposition political leaders at Bonn have struck an uneasy truce, with Dr. Schumacher apologizing to Dr. Adenauer for calling him a "Chancellor of the Allies," and in return receiving permission to return to his seat in the Assembly. Their wrangle has dumped the whole idea of German defense and rearmament into the political arena, and only a few short years after the war it is becoming obvious to the Allies that either a commitment will soon have to be made to defend Germany or to accede to some German plan of self-defense.

The Atlantic Pact governments allied together in Western Defense are now face to face with real operational planning now that the fancy top-level work has run its course with a great deal of committee-breeding, air visits back and forth, and paper swapping. Even with the support of $900 million worth of American arms it is obvious that commitments of money and men of all the countries involved must materially increase if principles and plans are to be turned into acts and pledges. One shake of Stalin's fist is worth far more than any number of General Montgomery's plans. The governments involved face grave and far-reaching decisions. The United States has belatedly assured the Europeans that they will not be the receptacle for American arms surpluses and that they will not be fobbed off with articles for which they have no genuine need.

All through the satellite countries bordering Russia a witch-hunt of extraordinary proportions continues to fell the mighty. Speeches of various party functionaries present a picture of party membership a jumble of agents provocateurs, spies and saboteurs. No party member can be trusted, however long his standing. Stalin is convinced that Titoism and the Anglo-American cold war in the "peoples democracies" merely repeats the Western interventionist campaign and Trotskyist subversion that were overcome in Russia. Stalin himself has given the warning that "a double-faced saboteur with a Party card, often hiding behind a screen of servility, seeming enthusiasm and high-flown dialectics is a much more dangerous enemy than an ordinary survivor of the hostile classes."

The Cominform met a few weeks ago in Budapest minus a number of familiar faces. Bulgarian Premier Dimitrov is dead and his Vice-Premier, Kostov, is being readied for the hangman for trying to "physically annihilate" him. The father of the Cominform, Zhdanov, is dead. Rumanian Foreign Minister, Anna Pauker, wasn't there. The survivors issued the usual pronouncements with all the euphemistic charm and grotesque self-deception of the communist vocabulary. Anyone opposing Soviet policies is a warmonger. Tito is now a fascist, and against fascism no holds are barred.

Over in the Asian theater of the cold war, the World Federation of Trade Unions (WFTU) met with great fanfare in Peking during the third week of November. But trade union affairs were not on the agenda—rather a blueprint of action for an Eastern Cominform was laid down, a blueprint of revolutions from Persia to Japan, comparable to that given by the late Zhdanov for

Europe at the initial meeting of the Western Cominform in 1947. The Western Cominform was devised to battle the Marshall Plan and the Eastern Cominform is to counter President Truman's "Fourth Point" of technical help for underdeveloped areas. Mao Tse-tung was kept in the background (Moscow doesn't want another Tito). Rather the main Moscow man in his cabinet, Liu Shao-chi, laid down the strategy: "Armed revolution must be the main theme in the people's liberation struggle, to be coordinated with other methods such as legal and illegal mass resistance in enemy-controlled areas and cities."

All this looks like 1950 will have pretty much the same impact on the nervous system as 1949. Or maybe more so!

Mining Geology—1949

by S. G. LASKY

WE seem to have assumed the careless habit in recent years of treating mining geology as synonymous with exploration geology, and exploration synonymous with exploration for new deposits—to be forgetting that mining geology includes also the geologic control or guidance of day-by-day mining operation. In the publicized romantic spotlight of the search for new deposits, we forget the man with the dirty overalls, grubbing away at the daily tasks of finding new shoots and of helping to keep production up and cost down.

Mr. Lasky is chief of the mineral resources section, U. S. Geological Survey, and an AIME Member.

During 1949, as in previous years, the resident geologist continued his quiet efficient functioning while the exploration geologist continued to stay in the spotlight—although this time he shared it with what may be called the resource-appraisal geologist. Many broad problems of national import—such as tax modification, the operations of the Economic Cooperation Administration, and certain international relations—have come up against an unexpected factor lurking in the background, namely, appraisal of world and domestic reserves and latent resources.

T. M. Broderick opened the year with his address as retiring president of the Society of Economic Geologists, wherein he analyzed the problems of exploration geology listing among them "the shortcomings of the geologists themselves, of the educators, the mining companies, our technical publications, the Federal Survey and Bureau of Mines, and the property owners."

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Research

Field and laboratory research in rock alteration carried over prominently from the preceding year—particularly in the form of papers by T. S. Lovering and others on Tintic, and by Reno Sales and Charles Meyer on Butte—and reached its climax in the symposium held at Golden, Colo., on the occasion of the celebration of the 75th anniversary of the Colorado School of Mines. An imposing array of speakers participated in that symposium: B. S. Butler, G. M. Schwartz, Harrison Schmitt, T. S. Lovering, R. H. Sales, Charles Meyer, W. S. Burbank, and Paul F. Kerr. The Lovering monograph on Tintic had already pointed up the difference between two major schools of thought, one of which considers alteration to be contemporaneous with ore deposition, whereas the other considers both as sequential episodes. The symposium further emphasized this difference and led many of those present to concur with the statement by B. S. Butler that "the problem is still fluid." "Someone," recommended Sales, "should now summarize the conflicting ideas and clarify the points of agreement."

Some of the major thoughts expressed at the symposium were: necessity for field distinction between weathering, sulphide oxidation, and hydrothermal alteration; the resurgence of Butler's old idea of alteration by acid solutions; comparison between some deposits and hot spring activity; leaching as an episode of alteration; and a "throttling" mechanism proposed by Burbank to reconcile the Butte and Tintic theories. The

EXPLORATION moved to the slow tune of strikes and price drops, but research pushed forward. Detailed study and sound geologic reasoning continued to find ore, but new stimuli are needed. Geophysics and geochemical prospecting are coming of age.

papers presented and the accompanying discussions will be published in the Colorado School of Mines *Quarterly*. Geologists are eagerly awaiting their appearance.

Geochemical prospecting gained momentum during the year. Concrete conclusions as to its usefulness and limitations are beginning to crystallize. As a result of three years' experience, the Geochemical Prospecting Section of the U. S. Geological Survey tends to feel that studies of vegetation are fruitful only in special types of problems. Studies of ground and surface water have been disappointing. The most promising avenues of approach appear to be study of the metal content of soil cover and river alluvium, and a study of disseminated metals in country rock surrounding blind ore bodies. Survey chemists have developed simple, rapid, semiquantitative methods of field analysis for traces of copper, zinc, cobalt, and nickel, and are now working on tests for other metals.

At least three companies have undertaken geochemical prospecting programs, and four others are reported to be contemplating such a move. As a matter of historical interest, however, it should be recorded that, so far as the writer has been able to learn, the Eagle-Picher Co., under the direction of George Fowler, introduced geochemical prospecting into American mining geology many years ago.

Industry is moving also into the field of geophysical research. Several companies have established more or less serious and continuous programs, and one company is reputed to have developed a new and successful method. Some advantage doubtless will come out of refining established geophysical methods in applying them to the search for ore, but it would appear that the greatest hope lies in imaginative research along new lines possibly suggested by the wartime advances in physical research and application. As scientists we are amusedly scornful of the witchstick. But also as scientists, may we not consider it presumptuous to assume that we are acquainted with all types of measurable energy and that we have the instruments to measure them?

Both public and private research, and applied geology as well, should benefit from the greater preparation in mathematics, physics, and chemistry now being required in geologic education.

Exploration

The status of exploration during the year depends upon the segment of the industry considered. Exploration of the iron ranges in Minnesota and Michigan continued unabated; more than one source of information indicates that iron exploration today "exceeds anything before in history save when the Mesabi was first being opened." It is reported that reserves are being rapidly augmented by several companies. Reserves of hematite ore in Labrador-Quebec, of carbonate ore in Ontario, and of ilmenite at Allard Lake in Quebec, continued to grow as a result of direct geologic effort.

Among the nonmetallics, fertilizers and lightweight aggregates received major attention. The search for pumice and perlite is everywhere a local matter, but the sum total of attention given to it has been large. Considerable drilling was carried on in the Carlsbad potash field, and the USGS expanded and intensified its long-term program there. The February meeting of the AIME featured a symposium on western phosphate mining, describing the activities of both

Widespread mapping of the earth's surface continued in 1949. Here, aerial maps made in conjunction with an airborne magnetometer survey are checked in the field against the magnetic data.

industry and the Federal Government. The paper by V. E. McKelvey, of the USGS, carries a prophetic note in its reference to fluorine, vanadium, nickel, and molybdenum in the phosphate deposits, and in the comment that these minor materials may eventually be recovered. To what extent are such minor constituents being overlooked elsewhere? Past examples of minor constituents converted into importance are molybdenum in the porphyry coppers, and tungsten and tin at Climax.

The search for uranium finds "frying pan Bill" using scientific instruments as effectively and nonchalantly as his predecessor used the gold pan. Much of the past official secrecy regarding uranium exploration has been dropped. The work of the Atomic Energy Commission and the USGS overshadowed most private undertakings. The Colorado Plateau continued to be both the major source of domestic supply and a major focus of geologic and drilling activity. Other investigations include studies by the USGS of the uranium possibilities of shale and phosphate deposits, mine and mill products, and selected mineralized areas. Columbia University and the University of Minnesota are doing mineralogic research for the Commission. In July, pitchblende was discovered in the Sunshine mine in the Coeur d'Alene district by a geologist of the Commission, and uranium-bearing minerals are reported to have been discovered also in vein deposits elsewhere. The importance of the finds have not been determined, but the fact of discovery is significant. The old proposition still holds: The more that is learned about the geology of a material, the more of it will be found.

Exploration for nonferrous metals lost momentum and came nearly to a standstill in the United States about midyear, accompanying the various shutdowns throughout the country. No new important discoveries, as measured by size, have been reported; but as measured by implications there have been two: (1) the successful conclusion of a long exploration program in covered country at Goldfield by Searls and his associates of the Newmont Mining Co.; and (2) the discovery of gold-silver veins in the northern part of the Tonopah district. Both were based on detailed geologic study and sound geologic reasoning. Both are better examples than San Manuel that it is possible to discover concealed deposits by good geology. San Manuel does have a cropping.

Explorations in the eastern states based on geologic studies continue to find zinc ore, with the result that reserves are now reported to be larger than before the war. Deep exploration is being continued at the Magma mine at Superior, in the Coeur d'Alene district, and in the Central district of New Mexico, predicated to a great extent on geologic theory. Generally speaking, exploration in the "snear zones" of established mines and districts appears to have continued to give the best results. In Canada, zinc-lead explorations at Pine Point on Great Slave Lake are being closely watched; the mineralized area is said to be comparable in size to the Tri-State district. The original discovery was made by direct interpretation of aerial photographs.

American capital continued active in foreign exploration, mainly, it seems, in continuation of existing programs. Prospecting on a grand scale continues in Africa, and large quantities of new ore were found during the year at known deposits. In Brazil, American capital and technology are assisting in the exploration and development of the manganese deposits at Urucum

and Amapa. In Peru, the Supreme Court of that country has ruled that the American Smelting and Refining Co. is sole owner of the Toquepala porphyry copper deposit, thus opening the way to development of the property.

The ECA has been actively attempting to sponsor and support exporation, development, and production of strategic and critical commodities throughout much of the world. The idea has been advanced that ECA activities have restricted the field of opportunity for private capital, but obviously this is a moot point. According to Evan Just, former director of the Strategic Materials Division, ECA's principal opportunities to improve the future raw material position of the United States under existing conditions are: (1) in increasing the productivity of participating countries in iron, copper, lead, zinc, aluminum, and fertilizer minerals; and (2) in fomenting exploratory activity in colonial areas.

A high light of the foreign exploration picture is the official record, made available in March 1949, of the development of the Zellidga Mines of Morocco through the collaboration of the original French owners, the Newmont Mining Co., and the St. Joseph Lead Co. The title of the official report—Two Years of French-American Technical Collaboration in Morocco—precisely reflects its contents. France may now be on the way to becoming a net exporter of lead and to becoming nearly self-sufficient in zinc.

An interesting feature of the entire exploration picture is the movement of the oil industry into mineral exploration and of the mining industry into oil. Presumably, the oil industry believes that it can make effective use of its geophysical know-how and of its state of mind. On the opposite side, it would seem that the mining industry believes that its capital can be better invested in petroleum than in mining.

Many reasons have been advanced to explain the decline in exploration. A. B. Parsons, who is making a study of the tax problem for the Bureau of Mines, has discovered that it is difficult to prove that exploration actually has declined. But whether it has declined or not is beside the point. The question to be answered is: Whatever the rate of exploration, is this country finding ore fast enough to keep up with the requirements of a growing population?

Several ways of stimulating exploration have been suggested. One is a modification of the mining law in order to eliminate abuses permitted by the present law and in order to facilitate most efficient application of modern geology and geophysics in the search for concealed deposits. The Hoover Commission Task Force on Natural Resources proposed eleven revisions in the laws pertaining to mining locations and four pertaining to the leasing laws. The Department of the Interior (including its National Minerals Advisory Council) and Congress also gave attention to this problem during the year. The Bureau of Land Management semipublicly distributed a sample revision of the law accompanied by a request for comment from all interested sources, including not only the mining industry but also other users of the land. The American Mining Congress at its convention in Spokane in September passed a resolution opposing changes in the present mining law, but in the face of many contrary expressions of opinion it is hard to accept this as the consensus of the mining industry, despite the Congress' wide membership.

The intensive search for uranium brought forth numerous varieties of Geiger-Müller instruments.

Modification of the tax structure as applied to mining has been aggressively proposed. The Interior Department has taken the initiative (with the advice of the industry through the National Minerals Advisory Council) in bringing the problem to the attention of the Treasury Department, and several exploratory conferences have been held by the two Departments. This problem is not peculiar to the United States. Venture capital in Europe, as well as here, is reported to be reluctant because of tax policies.

One reason why exploration is not on a greater scale may be a lack of complete appreciation of the fact that we have entered an era in which past scales of exploration—with respect to acreage, time, money, and perhaps luck—are too small. George Fowler writes: ". . . it is becoming increasingly evident that much more attention must be given

to areas of pre-mineral structural deformation, particularly those of large extent where deformation has been intense. It is probable that years of study will be necessary in some of these areas before many new ore deposits will be found."

Geologists are unanimous in their opinion that extensive regional mapping is a necessary background for exploration. It has been pointed out many times that most other countries are more completely mapped than is the United States. That is hardly a fair comparison, for they are smaller and have been at it longer. Nevertheless, it is a fact that other countries do appreciate the value of geologic mapping more than does our own. Witness the arrangements, developed through ECA, to recruit American geologists and geodesists for the British Colonial Service. Geologists of the USGS are now at work in half a dozen foreign countries under the sponsorship of the respective governments.

In order to determine the real status of mapping in the United States, Leona Boardman of the Geological Survey is making, and has nearly completed, an inventory of published geologic maps, providing for the first time an over-all picture of the location and extent of geologically mapped areas and of the scale of the maps. The inventory is being published in the form of state maps.

Resource Appraisal

In August there was held at Lake Success the first United Nations Scientific Conference on the Conservation and Utilization of Resources. The part of the Conference that dealt with mineral conservation centered about mineral resource appraisal and estimates of future demand. There was a general feeling that the world supply of mineral commodities is ample for all, but there was disagreement as to actual reserve estimates and as to degree of necessity for future discovery.

In the opinion of Julian Feiss, who reported on the Conference in the October issue of *Mining Engineering*, the Conference "indicated beyond all shadow of a doubt that one of the most important problems in respect to minerals conservation is that of proper appraisal on a world-wide scale . . . One of the lessons that the Conference drove home was the necessity for more attention to the problems of fundamental geology as applied to mineral resource appraisal."

A. B. Parsons, in reporting upon the tax study mentioned above, has concluded that to document conclusively the case for modification would require data that could be obtained only through a continuing inventory of reserve and resource data. Examples of the need for such data can be multiplied almost endlessly. The series of articles in the *Engineering and Mining Journal* on the mineral resources of the ECA countries constitutes valuable reference material in this general connection.

It is common to hear talk about shortages of food, or coal, or steel, or plant capacities, or labor; but shortage of authoritative data can be just as harmful. Because of this the emergence of the new Section of Mineral Resources of the USGS merits mention. Broadly speaking, its purpose is to maintain a continuing "inventory" of mineral resources and of geologic knowledge relating to appraisal and exploration.

It is regrettable that the mining industry does not have a counterpart to the American Petroleum Institute, which compiles statistics on petroleum reserves officially for the petroleum industry. It would seem feasible to expand the American Bureau of Metal Statistics to make it a clearing house for such information.

The year has in many respects been a transition period, in which it is difficult to pick out the most significant items. Exploration tapered off accompanying labor strikes and the drop in metal prices; but some companies that give great weight to the geologic side of exploration are continuing their activities. The example of the Anaconda Copper Mining Co. in establishing a research department is being followed by others, each in its own fashion. History repeats: Anaconda was also the first mining company to create a geologic department. The alteration symposium at Golden probably presages more detailed alteration studies in the future, and more practical application of these studies in the search for ore. Of great potential significance is the degree to which Government and the mining industry joined hands in attacking mutual problems.

Whether recognition of the critical value of mining geology has advanced during the year is difficult to say. Many companies are placing increasing reliance upon their geologic staffs in both exploration and daily operation, but still others consider exploration, in Broderick's words, "a sort of luxury to be indulged in only when times are good." Some are reported to have switched their emphasis from exploration to improved metallurgical technology. Mining geology does not gain or lose recognition on its merits alone; it depends to a great extent on the advance or retreat of exploration itself. In this connection, Fred Searls, Jr., raises the point that this country eventually may have to rely on foreign sources for some metals not because it does not have them here but because it may have difficulty getting the labor to mine them. "Few people," he writes, "realize the extent to which the 'old timers' are still the backlog of the important districts."

I cannot end this review without calling attention to two publications that have appeared during the year: the second edition of the Institute's "Industrial Minerals and Rocks;" and a book by Isaac F. Marcosson entitled "Metal Magic—the Story of the American Smelting and Refining Company" (Farrar, Straus and Co., Inc., N. Y.). The titles speak for themselves. John Brown's "Ore Genesis," which appeared late last year and which submits a new theory of the origin of ore deposits, is arousing widespread discussion.

Many friends and acquaintances throughout the industry have contributed information for this review and I wish to take this means of thanking them. Some are identified by the quotations credited to them; the full list is far too long to repeat.

Underground Metal Mining—1949

by E. D. Gardner

The tide of increasing demand for metals turned during early 1949, with resultant lower prices. The production of the principal metals was less than in 1948. The problem of high unit costs, however, was held over from 1948. With the lower prices for metals, greater efforts are being made to reduce operating costs.

The labor supply was adequate during the latter half of the year in most districts. The force has been reduced at most mines; some mines were idle during part of the year because of strikes, and others ceased operations on their own account. In the main, labor efficiency increased during the year in underground metal mines. Efforts are being made generally to improve labor relations. Green men hired in the time of the scarcity of skilled miners are becoming better trained. The supervisory personnel of most mines is cost conscious, and the planning of operations has been improved. Overhead costs are being scrutinized.

The trend toward mechanization underground continued strong. Mining technology rapidly is becoming a problem of handling materials. Surface miners, underground miners and miners of metals, nonmetallics, and coal can learn much from each other. A mine, however, may become overmechanized. The capital charges against new equipment may exceed the saving in labor costs where sufficient daily tonnage is not handled.

The author is chief mining engineer, U. S. Bureau of Mines, Washington, D. C. and an AIME member.

Shaft sinking.—A successful machine for mucking in inclined shafts has been developed at the Bunker Hill & Sullivan mine. Two machines are used in sinking the Bunker Hill auxiliary shaft. They are fastened to the main hoisting ropes and operate in balance on 40-in. gauge track. Essentially a machine comprises a heavy frame with a slide and a boom. Pivoted between two arms at the lower end of the boom is a 20-cu-ft bucket. The bucket does the digging, and is operated by compressed-air motors through a downward arc. When the bucket is filled, the machine is hoisted to the level above and the bucket dumped into a hopper. Two machines in the Bunker Hill shaft loaded out a 6-ft round comprising 130 to 220 buckets in 6 to 8 hours.

The use of a hydro-mucker in sinking the Mather "B" shaft of the Cleveland-Cliffs Iron Co. at Ishpeming, Mich., is of considerable interest. This machine consisted of a hydraulically controlled clamshell operated from a movable staging in the shaft. The clamshell dug the material from the shaft bottom and placed it in a mucking pan, which in turn was hoisted by an air motor on the movable staging and dumped into a mine car on the cage. Since the clamshell was suspended from a hoist on the staging, it was extremely flexible and virtually the entire shaft could be cleaned without shoveling.

The use of the Riddell mucker in sinking No. 1 and No. 2 shafts at San Manuel has shown a definite economic and operational advantage over hand-mucking methods. This is true, even though mechanical mucking has been handicapped, in some instances, by the necessity of supporting the shaft walls to the bottom.

An improved procedure for taking 6-in. cores with diamond drills has been developed in the petroleum industry. Experiments made by the Bureau of Mines at Mount Weather, Va., indicate that an advantage is to be gained by setting the diamonds of a cast bit in a definite pattern.

Mining methods.—An improvement in shrinkage stoping has been devised at the Idarado mine. Main haulage levels may be up to 500 ft apart. Scraper drifts are run at 100-ft intervals. Raises are driven from the haulage level at bends of the vein and at the optimum distance apart for scraping. The ore is drawn through draw holes into the drifts and slushed into the raises by means of a 13-cu-ft bucket; the hoist has a 2600-lb pull.

Development costs have been cut at Climax by a change in the undercutting technique. Parallel drifts are driven from the top of finger raises. Long-hole blastholes are drilled in rings in the drift; blasting breaks the pillars and completes the undercut.

Block caving is being adopted successfully by Cleveland Cliffs for mining bodies of soft iron ore.

In five months' time a production of 500 tons per day was attained at the Reeves MacDonald mines, Salmo, B. C. Ore from horizontal open stopes and from removable pillars is slushed into a raise.

The Bureau of Mines made a production test run on a unit scale at its Experimental Oil-Shale mines at Rifle, Colo., in September and October; 16,900 tons were mined from the top or heading level in 27 by 60-ft faces and 15,660 tons from a bench 23 ft high and 60 ft wide. The average direct cost was $0.292; an average of 148.2 tons was broken per man shift underground and 116.1 tons for all labor, including direct supervision, direct engineering, and maintenance.

Some of the underground limestone mines in the Mississippi Valley have long used portable air compressors underground which are moved up as the faces advance. To save the cost of laying and moving air and water lines and to eliminate line losses, the Bureau of Mines designed and had built a movable electric compressor unit that supplies 1500 cu ft of air to four 4-in. percussion drills used in 27 by 60-ft headings; it has proved successful. The idea would appear to have merit elsewhere where conditions would be favorable.

The highly successful Riddell shaft mucker in action, suspended 30 ft above shaft bottom.

Drilling.—The use of jumbos is increasing underground. A 2-drill jumbo operated by one man has appeared for drilling drift rounds. The Bureau of Mines has developed a 4-drill jumbo run by two men for drilling down holes on a bench in its Oil-Shale mine. The four 4-in. wagon drills are mounted on a tractor.

The latest in jumbos has been developed at the Eagle-Picher mines. It comprises a crawler-type chassis, carrying a telescoping mast which can be extended to a height of 65 ft. A drill using a 12-ft mast is mounted on a platform at the top of the mast. It is used for taking down roof.

Study of rock-drilling practices at the Holden mine continued throughout 1949. The feasibility of drilling long holes with percussion drills, 2-in. tungsten-carbide bits and extension steel became apparent in 1948. Continued study and use developed this method in 1949 to the point where diamond drills could be eliminated, except in special cases requiring holes longer than the 70-ft limit in normal ring patterns.

At first, bits were retired when one insert was lost or the gauge had dropped below $1\frac{13}{16}$ in. the smallest-diameter hole that will take $1\frac{3}{4}$ in. powder. Later on, it was found that bits with only three inserts intact would still drill. To prevent a partly broken insert from coming loose in a hole and damaging good inserts, the broken in-

serts are ground down ¼ in. or so to prevent contact with the rock. Now, these reclaimed bits are returned gradually to the circuit together with new ones. Bits below usable gauge are being saved for future use on special holes or routine development headings.

Through the maximum use of bits, improved shop practice, and better drilling technique developed by the miners, drilling long holes by percussion drills and 2-in. tungsten-carbide insert bits can now be done for about 25% of the former cost per foot using diamond drills. Results to date have been as follows:

	Year 1949, First 10 Months	*Since Started, July 1948*
Feet drilled	68,480	90,512
Bits used	460	757
Feet per bit	148.9	119.6

After the success of tungsten-carbide bits for drilling long holes was definitely assured, experiments were begun using 1½-in. insert bits in direct competition with a one-use bit that had shown 1.96 ft per bit for 424,062 ft of drilling during 1948. The advantage of the insert bit was quickly apparent because of the increased rate of penetration with small loose gauge, but difficulty was found in getting the bit studs to stay tight. This objection was overcome by devising a complete new jack-stud connection, which is made in the steel sharpener.

Drilling experience in development headings for the first ten months of 1949 is shown by the following tabulation:

	One-Use Bits	*Insert Bits*
Feet drilled	166,016	218,540
New bits	25,950	1,564
Feet per bit	2.14	139.73
New rods made	803	605
Rods reconditioned	2,611	3,588
Feet drilled per rod use	48.63	52.12

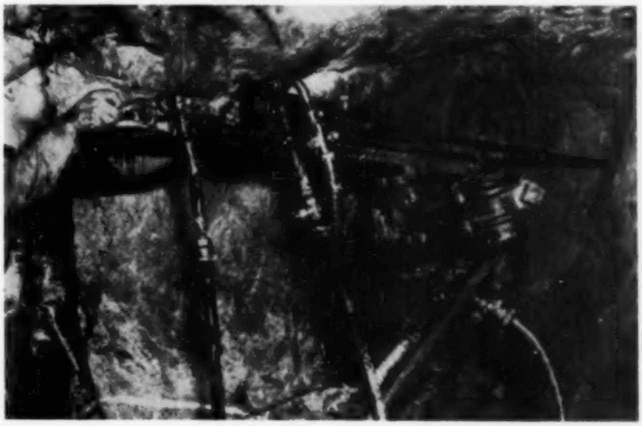
Insert bits were adopted for general use on April 1, 1949. Increased drilling rates permitted bonus prices to be reduced appreciably. Moreover, with the adoption of these bits the use of a jumbo with an 8-ft feed became a reality. It also will be noted from the above tabulation that more footage was drilled per drill rod with the insert bits, thus making a further saving.

The successful adaptation of percussion drills and tungsten-carbide bits to long holes has opened many interesting possibilities at Holden besides ore breaking, such as reaming shafts to a pilot raise, sideswiping tunnels, and cutting hoist rooms, stations, and ore pockets. Such excavation work has been done successfully with diamond drills in the past and should be done much cheaper and easier with percussion drills now.

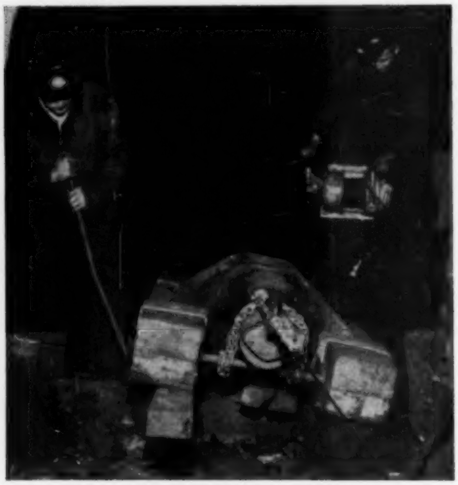
Future research programs at Holden will include comparison of alloy and carbon drill steel, possibility of improving jack-stud driving, trying out various types of insert bits and conventional steel with insert tips, investigating performance of down-stroke rotation in rock drills, and application of long-hole drilling to all phases of mining wherever possible.

The Cleveland-Cliffs Iron Co. at Ishpeming, Mich., has conducted a long series of exhaustive tests on insert-type bits compared to detachable steel bits. Nearly all of the company drilling operations are now using tungsten-carbide insert-type bits. To continue the tests, the company is investigating the performance of lighter, faster machines with reverse (downstroke) rotation. Currently, a machine producing one rotation of the steel for each 50 strokes of the piston is being tested.

The insert-type carbide bit is also being adopted by other mines. Conventional bits and those of the "throw-away" type are holding their own, however, at many places. Many feel that further improvements in the carbide inserts will have to be made, and the first cost of bits will have to be reduced for them to be universally accepted. The carbide-insert bit, however, has a definite advantage in hard ground where long drill feeds are used.



The use of jumbos is increasing underground. This Ingersoll-Rand boom jumbo is shown driving a tunnel.



A small hoist (right) being used to move an air shaker in an underground chamber.

Homestake has continued test work on both standard and tungsten-carbide insert bits during the year but has not yet reached a decision as to a change from conventional bits. The company has also been testing tungsten-carbide insert bits in the 3-in. size for drilling the burner cuts in drifting with considerable success, but it is not yet beyond the test stage.

Considerable experimentation has been done at the Bunker Hill & Sullivan mine with various types of drill bits, and particular attention has been paid to the single-use type, as well as to those with tungsten-carbide inserts. Numerous tests also have been made on drilling rods, with particular attention to rods of alloy steels. Some work has also been done in connection with the use of smaller and lighter pneumatic drills, using smaller drill bits than heretofore. Further experimentation has also been done in connection with the use of the millisecond-delay blasting cap. Tests on drill bits have indicated that the throwaway bit had distinct advantages under some conditions existing at that mine. A comparison of costs for bits per foot drilled in sinking 1100 ft of the Bunker Hill shaft was as follows: Jack bits — \$0.055; Tungsten-carbide — \$0.08; Throw-away—\$0.012.

Eagle-Picher is experimenting with throwaway bits of a smaller diameter than the conventional detachable bits in use, and tests so far show a saving of about 25% in the cost of bits. A further saving in explosives also is recorded.

The breakage of drill rods remains an important item of expense at many mines. Considerable attention was given to the problem during 1949 by mining companies. The manufacturers of drill steel also became interested in the problem during the year.

A number of companies have been experimenting with alloy-steel drill rods. The results, on the whole, are not conclusive; two companies reported high breakage of shanks. The use of alloy drill steel in San Manuel shaft sinking operations has proved an economic advantage in reducing rod breakage, thus lowering drilling costs.

The bit end of drill steel used with one throwaway bit requires no forging. This should be an advantage in prolonging the life of the drill rod.

Blasting. — One of the explosives companies has produced a free-flowing powder for pouring into 2-in. down holes for blasting underground benches in the Bureau of Mines Oil-Shale mine. The explosive has satisfactory fume characteristics, and compares favorably in its breaking qualities to the stick explosive used in the horizontal headings.

Experiments are being made with millisecond-delay detonators at a considerable number of mines, and they have been adopted at some places. Reports of the experiments indicate that better fragmentation is obtained; secondary blasting has been reduced up to 30% in hard ores. Also, there appears to be less overbreak and fewer cut-out holes. Fewer holes per round are required and also a saving in explosives is reported. Disadvantages are greater spread of the broken material and increased breakage of timber.

Experimental work on electric millisecond-delay blasting was conducted at the Magma mine in both square-set and horizontal cut-and-fill stopes. Fragmentation was definitely improved. The timber, however, in the square-set stopes could not withstand the effect of continuous blasting produced by the millisecond delays.

The Bureau of Mines has been experimenting with millisecond delays at its Mount Weather, Va., experimental mine. The tests indicate that the holes of a round may be drilled at right angles to the face, and no extra holes as used with "burn outs" are needed. A saving in both the number of holes and the amount of explosives required is recorded. The disadvantage is that the blasts are likely to clean the timber out of the raise.

Eagle-Picher has found the use of Ignitacord gives a saving in cost over fuse, and the hazard is also greatly reduced. It is believed that it has good possibilities in pattern shooting.

A new type of mucking machine locally called the "Gissmo" is in operation at the Grandview mine at Metaline Falls. The machine loads itself with a bucket-type nose and moves the muck to the unloading station by dragline hoists where it automatically dumps.

Haulage. — Numerous underground installations of conveyor belts and shaker conveyors have been made, especially in the Gogebic and Menomee Ranges of Michigan. Additional installations are being made or are in the planning stage. Conveyor transportation in place of slushing or tramming has been installed in connectors with the Bunker Hill block-caving system for transporting ore from the crusher to the ore passes. Conveyor equipment is now being installed in the new main incline of the Pend Oreille Mines & Metals Co. Other work is pro-

gressing rapidly toward starting production. Rubber-tire haulage is gaining in underground mines where conditions are favorable. The use of Diesel-powered equipment underground in 1949 continues at about the same level as during 1948. The Bureau of Mines issued a new schedule for testing Diesel engines for use underground in noncoal mines, but no actual testing of equipment has been done.

The Ruth Co., Denver, Colo., designed and built a small Diesel-driven locomotive for use as a trammer in metal mines. It is equipped with an exhaust scrubber, and the power is delivered through a fluid drive. The first unit was delivered to a mining company in Tennessee late in 1949. A metal mine near Salmon, Idaho, expected to receive a Diesel locomotive for underground use during the fall of 1949. The Eagle-Picher Mining Co. continued to use Diesel-powered trucks underground, and has increased the number of units in service. The Horse Creek limestone mine in Wyoming is using two Diesel-powered locomotives in underground haulage service, and reports excellent costs of operation. Numerous inquiries regarding Diesel equipment were received by the Bureau of Mines, which indicates the increased interest in this type of underground haulage units.

Bolting of roof stones to strata above to support the back has been followed for many years, as in high stopes of the lead mines of southeastern Missouri where other means of support would not be practicable. The practice is now being greatly extended, particularly in the coal mines of the country. A hole, usually up to 6 ft long, is drilled by a stoper, and the bolt is held in the hole by means of an expansion head. The costs of supporting backs by bolting is slightly higher than by conventional timbering in flat deposits. The absence of timber, however, permits a substantial increase in operating efficiency and reduces the fire hazard. Although a bolt with an extra large washer usually suffices, steel caps supported by two bolts can be used.

Steel sets for support are proving cheaper than timber in some areas. A two-piece arched set made of discarded 80-lb rails has been developed by the Empire Star Mines, Ltd. It is bolted together at the top of the arch.

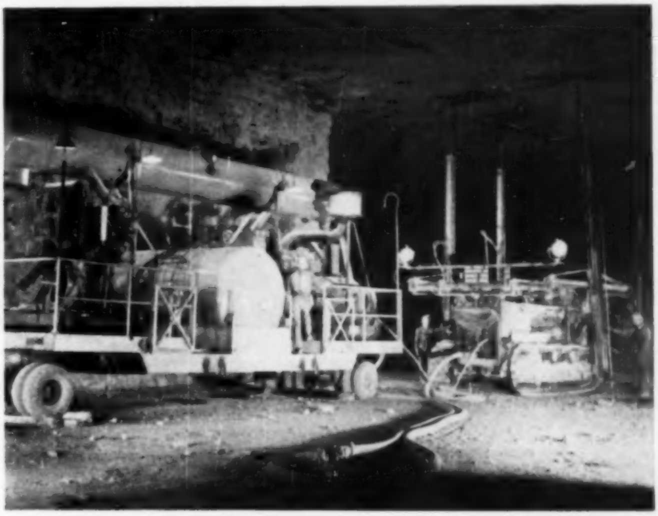
Timber costs, like those of other mine supplies, have advanced over pre-World War II days. Numerous wood preservation plants have been installed where sizable quantities are used and atmospheric conditions underground are such to promote decay. At the Mather "A" mine, prefabricated steel reinformed concrete logging is used between steel sets.

A manufacturer has markedly improved the design of mine hoisting equipment by: (1) The introduction of roller bearings throughout; (2) affixing brake-lining blocks to the hoist drum, instead of tooth-brake shoes; (3) uniquely reinforcing the interior of the hoist drum with steel plates; and (4) adding an electrical telltale for proper positioning when meshing the tooth clutch.

The problems of pumping acid water and of stream pollution largely have been solved at a Tri-State mine by piping milk-of-lime from the surface under pressure into a sump which is the intake of the mine pumps. The lime neutralizes the acid and the high pressure agitates the sump and prevents sedimentation.

This article was prepared largely with the help of other members of the Institute by correspondence. The assistance of the following is especially acknowledged:

John J. Curzon, J. B. Haffner, Charles A. R. Lambly, S. S. Clarke, W. P. Goss, Guy N. Bjorge, J. H. East, Jr., Paul Zinner, J. Murray Riddell, and John V. Beall.



A movable compressor operating in conjunction with four 4-in. wagon drills mounted on a tractor, used for drilling down holes on a bench at the Bureau of Mines Oil-Shale mine.

Health And Safety In Mines

by S. H. Ash

Mass production methods, although increasingly important for economic reasons, create new hazards, remove many hazards, and improve health and safety by reducing exposure and obtaining better supervision. Such methods must be efficient or be discarded. Skilled workmen are required who must be trained to utilize equipment that replaces picks, shovels, and explosives.

The author is chief, safety branch, health and safety division, Bureau of Mines, Washington, D. C., and an AIME member.

The effects of working conditions on the health of workmen have long been evaluated in noncoal mines. Studies and action programs relating to environmental health hazards in the mineral industry have placed particular emphasis on dusts. The anthracite industry is conducting an action program on the problem of dust. Segments of the bituminous industry are now conducting similar investigations.

An industrial hygiene survey of coal mining in the State of Washington has been conducted and the results published in 1949. (State of Washington, Department of Health, I. H. Bulletin 4.) Chest X rays were obtained from miners in the six major coal-producing counties. State Health Department mobile X-ray equipment was set up at most large mines. Participation was on a voluntary basis, and response was obtained from 70 percent.

Important in successful mining safety programs are training programs for supervisors and workmen alike. These programs recognize that the employe is the focal point in injury prevention and are planned and function around him.

During the war, industries had to compete with each other for workers and to obtain and hold good workers, working conditions had to be made attractive. The average age of the mine worker increased, and, contrary to what many expected, mining injury rates decreased rather than increased. To attract competent workers, risks to life and limb, as well as laborious tasks, have to be reduced, and an experienced worker is indispensable for safety.

Young men are returning to modernized mines. Mass production methods and equipment are more to their liking; jobs are more remunerative, demand action, and require special training and skill that give them the mark of a craftsman. Such workmen can be taught safe methods.

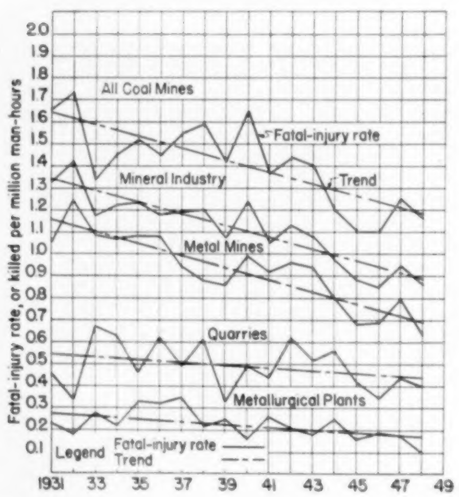


Fig. 1. Fatal injury rates for the mineral industry are declining.

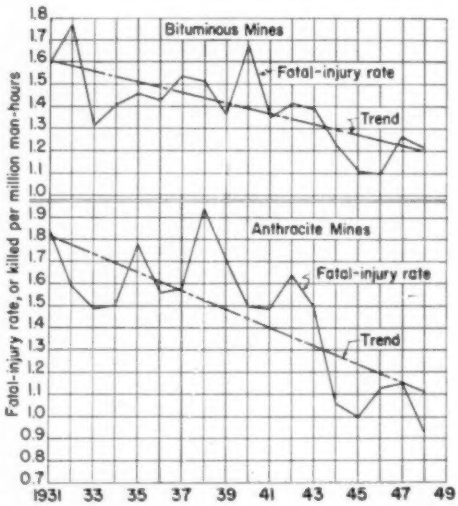


Fig. 2. Improvement in fatality rates in anthracite is more rapid than in bituminous.

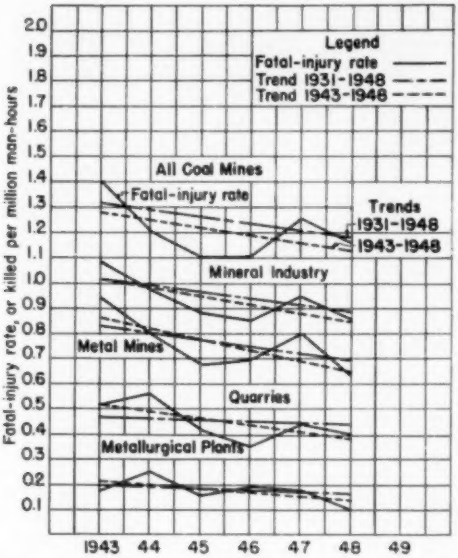


Fig. 3. The trend in fatalities in metal mines is better than in any other branch.

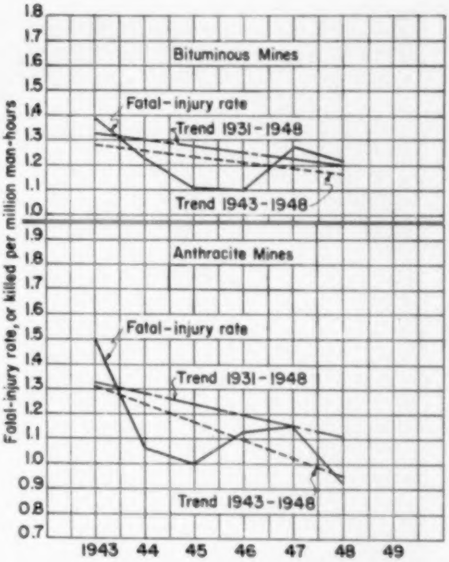


Fig. 4. 1949 shows all-time low for fatalities in anthracite mines.

Safety conferences continue to gain in popularity, and those held during the year by the Lake Superior Mines Safety Council, Montana Section of the National Safety Council, Utah-Nevada Safety Society, and the mining safety meetings at the conventions of the Coal Mine Inspectors Institute of America, AIME, American Mining Congress, and the National Safety Council were the largest meetings in their histories.

Research on the use of steel cross bars bolted to the roof or supported by pins in the ribs is being conducted in some mines in all branches of the mineral industry. This is being done both for economic reasons and in the belief that it will prevent many injuries from falls of roof, the major cause of injuries in mining. In the past 19 months, 188 mines have been examined and more than 250 miles of openings have been supported by roof bolting.

Diesel power is becoming more widespread underground in noncoal mines. To date, Diesel equipment is not used underground in coal mines in the United States; however, there is no good reason why, for safety and economic reasons, such equipment could not be used in many coal mines. Education regarding Diesel equipment should be widespread.

Mining safety education is fundamental for favorable public relations. Those engaged in formulating curricula in mining colleges could well afford to give consideration to mining safety as part of mineral industry education. Some colleges require first-aid training for mining students. Those engaged in accident prevention programs believe that first-aid training is the best foundation upon which a safety program can be built. Demand for this work is increasing.

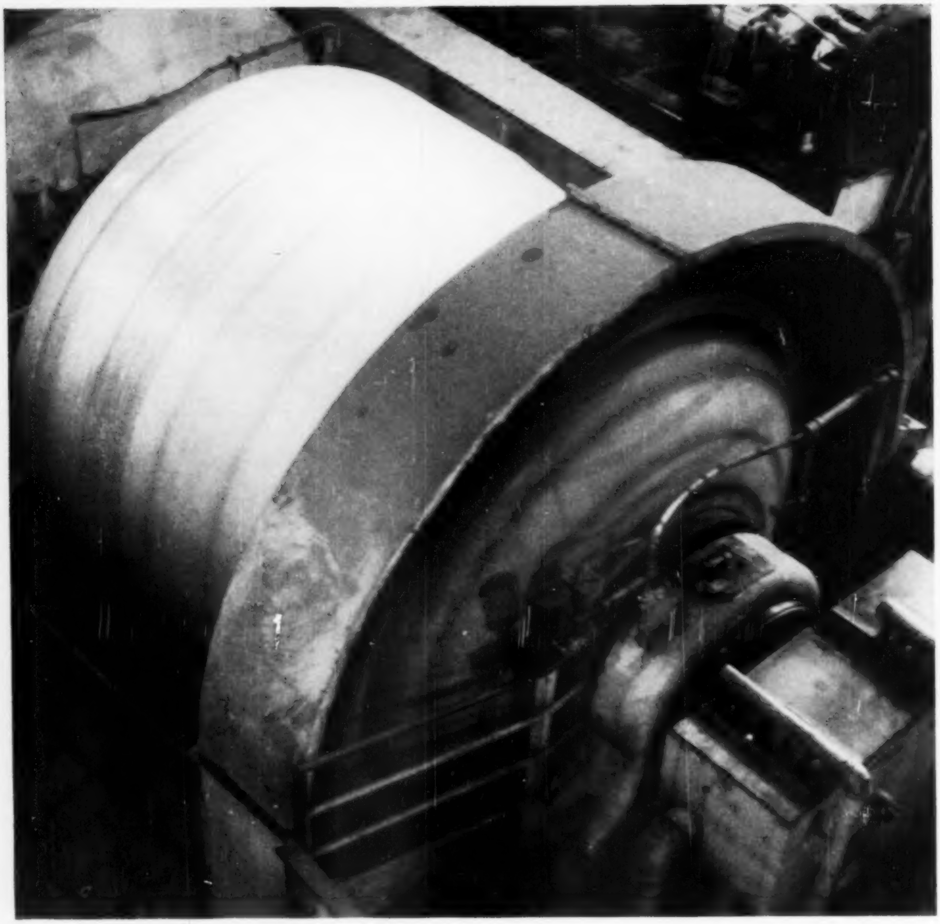
Statistics are necessary to show whether safety in the mineral industry has improved during 1949—or is improving. Despite what may be said to the contrary, progress has been and is being made in mining safety as is shown in Figs. 1 to 4.

Because of intensive safety work in the larger metal mining operations, the metal mining branch shows a greater and more consistent reduction in the fatal injury rate. Anthracite mines, employing 80,000 persons, show the greatest downward trend. The fatality rate per million man hours for the anthracite industry for 1949 to date (January to November) is 0.78. This rate is 15% better than (0.92) achieved during 1948, which was the lowest fatal injury rate achieved in our coal mining history.

Complete statistics on injuries during 1949 are not available for the entire year. Statistics available show a definite downward fatal injury trend.

An outstanding accomplishment in mining safety is that a major disaster has not occurred in the mineral industry during 1949.

Because of large employment in the coal mining branch (bituminous and anthracite), a noteworthy achievement has been established in that 1949 is the first full year on record in which a major disaster has not occurred in coal mining. The last major disaster in coal mining occurred on Nov. 4, 1948, and, to date, a record number of days have elapsed between major disasters in coal mining.



Minerals Beneficiation in 1949

S. J. Swainson, Editor

PROGRESS has been made by improving existing methods. New developments in grinding, flotation, forced gravity separation based on study of fundamental principles. Improved design of equipment also heralded increased efficiency.

"It appears to me that the chief progress in milling operations in America have been made in the steady improvement of existing practice through both higher extractions and increased efficiencies of operations rather than by the development of new processes. The recent rapid development of sink-float, or heavy-medium separation, however, is an exception, and is becoming increasingly used to permit the economic treatment of certain low-grade ores that otherwise could not profitably be mined. The use of spirals and of small cyclones, both of which employ the principle of centrifugal force, show promise of increasing adoption through their application and efficiency in special cases."

So did our distinguished colleague, O. A. E. Jackson, consulting metallurgist for the Union Corporation and president of the Chemical, Metallurgical and Mining Society of South Africa, summarize his impressions of a recent tour which he made of various metallurgical and milling plants in North America. I believe that all mineral dressers will agree with Dr. Jackson's concise conclusions.

Grinding

J. F. Myers and F. M. Lewis, Tennessee Copper Co., created quite a stir at the Columbus Mid-Year Meeting with the results they reported from the use of their new 11-ft Hardinge Tricone mill. They reported a net gain of 22.6% in mill efficiency (tons of minus 200 mesh produced per kwhr), by substituting this mill for two 5 by 12 and one 6 by 12-ft ball mills. They credit this improvement to increased diameter, low speed, water lubricated bearings, new motor, and correction of ball alignment, due to Tricone construction. They found by test, previous to the change in mills, that a reverse ball segregation existed in their older mills, just as did W. I. Garms of Kennecott Copper and also E. H. Rose, then superintendent of International Nickel. This reverse segregation, they note, was corrected by Garms after he installed a Tricone lining in one of his 7 by 10-ft mills and gained 6% efficiency by this one change. They also report another 6.1% improvement (28.7% in all) when they decreased mill pulp density and added Dorr's "Hydroscillator" classifier to this circuit. More about all of this will be forthcoming at the AIME meeting in February, 1950.

Multistage grinding is again coming into favor in some localities. At Lake Shore, milling is carried out in five stages employing small circulating loads, the final stage of grinding using ¾-in. balls. Recent reports indicate that the primary experiment at Lake Shore, using a tube mill operated as a pebble mill, is so successful that the company intends to convert additional tube mills to pebble mills using the ore itself as the grinding medium.

T. C. King of Eagle Picher Lead Co., has found a unique use for a spiral classifier. Where the feed from the bin is wet and tends to flow, he placed the spiral classifier below the bin outlet, added water into the bottom of the bin when necessary, and used the action of the spiral in the classifier to regulate the feed to his ball mill. Strohl and Schwellenbach, at the MacIntyre mill of the National Lead Co., report on the effect of rod-mill-feed size reduction. Decreasing the feed from ¾ to 9/16 in. limiting screen size, the capacity was increased from 38.4 tons to 42.4 tons per hr. Rod consumption was decreased from about 1.8 to 1.7 lb per ton and liners, .076 to .065 lb per ton.

"Rod Milling Comes to the Rand" is the title of an article that appeared in the Oct. 28, 1949 issue of the *South African Mining & Engineering Journal* describing the rod mill that has been installed in the Marievale Consolidated mines of the Union Corporation, east of Johannesburg, South Africa. This rod mill is 6 ft in diameter by 12 ft long, and provision has been made to vary its speed of rotation. The rod charge will be of high-carbon steel ranging in size from 2½ to 3½ in.; the rod volume will be approximately 40% of the mill volume.

Consolidated Mining & Smelting Co. in Kimberley, has been experimenting with the largest rod mill ever built. No data has yet been pub-

Mr. Swainson is director of ore dressing for American Cyanamid Co., and a member of AIME.

lished, but many mill men will be eagerly awaiting Bert Banks' report.

Anaconda has also been experimenting with a large rod mill as a fine crushing unit replacing rolls and smaller ball mills. It is reported that rod mills will be used as fine crushers in the new mill of Chile Exploration at Chuquicamata.

Reports from the field are showing a definite trend to increase the height of lifters in rod mill liners. Wear is shown to be extremely low, so long as the lifter bar stops the tendency of the rod mass from slipping. Not all mills show a tendency for the load to slip on relatively smooth liners, but those that do get out of trouble by using the high lifters.

Ball-wear tests, reported by D. W. Norquist and J. E. Moeller of Sheffield Steel Co., have made wear-rate tests of 4 to 2 in. diameter forged steel grinding balls in operating mills. The results indicate that all the balls in a given mill, under the same conditions, have equal diameter losses regardless of size.

A. E. Matson of Butler Brothers, Louis Erck of Cleveland-Cliffs Iron Co., and R. C. Ferguson of Hardinge Co. state, in a paper presented by Erck at the Columbus Meeting, that improved results on the Mesabi Range are obtained using ball mills to crack intermediate iron ores high in silica. Better separations are reported, thus increasing the grade. The operation is termed "abrasion milling." They state that this operation makes it possible to treat certain ores on the range which heretofore were not considered amenable to treatment, thus increasing the reserves available by including these leaner horizons.

Classifying

Dorr has improved his classifier known as the heavy duty "HX" by the use of a harmonic motion, automatic recirculating filtered-oil lubricating feature and hydraulic-lifting device. Donald Dyrenforth, of the same company, reports in the Colorado School of Mines *Quarterly*, that a study made of operating data of 50 mills supports the DeVaney-Coghill published demonstration that ball wear is proportional to mill power rather than tons of ore milled.

Franklin Davis of Magma Copper Co., Superior, Ariz., reports good results with a different type of Esperanza drag classifier. This classifier uses a perforated rubber belt with sprays and belt scraper in a regrinding copper concentrate circuit. He states that this classifier in this circuit has the advantage of low power consumption, low first cost, and excellent classification.

Hydraulic cyclones (similar to the Dutch State Mines cyclone) are being successfully applied in several plants in the field of fine-size classification and desliming. In one such application, the cyclone is used ahead of a Bird centrifuge and in series with it for the purpose of relieving the sand load on the centrifuge. With this combination, it was possible to double the capacity of the circuit while at the same time reduce the speed of the centrifuge by approximately 40%. In another application, two 12-in. cyclones are used to classify, thicken, and deslime a gravity-plant tailing to produce a feed for a soap flotation circuit. The two cyclones receive a pulp containing 5% solids. They produce 100 tons per day of flotation feed with a weight recovery of 75%. The underflow from the cyclones, which goes to flotation, contains 65% solids. The two cyclones are fed by one 5-in. Wilfley pump operating at 40 psi and 450 gpm of pulp.

Tennessee Copper Co. reports its continued use of the old style verticle-type 48-in. Symons crusher. The speed has been increased far beyond the manufacturer's original specification, and with improved lubrication it does a splendid job of fine crushing. The increase in speed not only increased the capacity but the centrifugal force permitted it to shed wetter ore than would be possible with the later design of cone, which has only the pull of gravity to clear the finished product. They ask the question "Have the manufacturers missed a bet?"

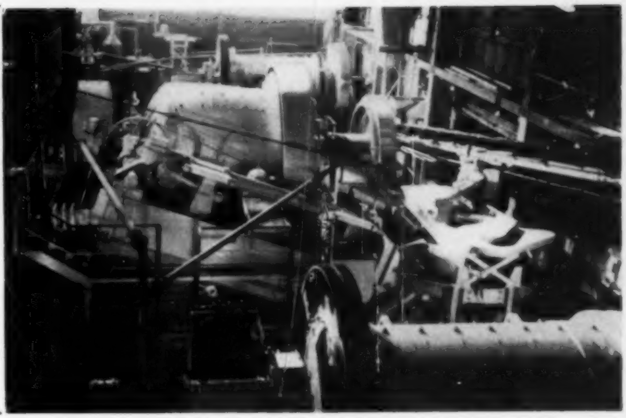
F. C. Bond, chairman of a special research committee on comminution, is correlating crushing and grinding data for use by the Institute. His committee is finding difficulty in establishing a working hypothesis that will cover all operating conditions. The various methods used to determine grindability of ores are highly contradictory. Means to bring these to some common denominator are now under consideration. A solution, if possible, to this problem would mark a real step forward in the art of comminution and operation of crushers and grinding mills.

Two very interesting papers this year, dealing with energy relations in crushing, appeared in *Chemical Engineering Progress* for August and November 1949. The authors were E. L. Piret and co-workers of the University of Minnesota.

In the first paper, they found a straight-line relationship between the energy input in crushing several brittle materials and the new surface produced. The surface was measured by the fluid permeability method. The slopes of the straight line decreased in the order fluorite, calcite, glass, and quartz.

In the second paper, study was made of the energy-surface relationship for halite for which both theoretical and experimental surface energy values are known. The theoretical values are of the order of 0.0001 kg-cm per sq cm. Gross' value, determined by crushing, was 0.0404 kg-cm per sq cm, whereas the present authors' value was 0.09. This gives an "efficiency" of the order of 0.1%. Calculated values for the surface energy of quartz are of the order of 0.001 kg-cm per sq cm, and based on the figures in the authors' first paper this gives a crushing "efficiency" of the order of 0.5% for quartz.

The authors have also found definite evidence of plastic deformation in the crushed halite by the use of X-ray powder photographs. In other words, part of the energy used in crushing produces plastic strain and is not used in producing new surface. This is the first positive evidence for plastic deformation in crushing of which I know. Plastic deformation will not occur in truly brittle material.



Tennessee Copper's 11-ft. tricone mill in closed circuit with the "hydroscillator" classifier is making history.

Heavy-media Separation

Undoubtedly, heavy-media separation leads all concentrating processes as regards new installations. During the year a total of 31 heavy-media plants were installed—17 on coal, 5 on iron ore, 2 on fluorspar, and the remainder on other metallic and nonmetallic ores. A 12,000-ton-a-day heavy-media plant is under construction at the Premier Diamond mines, Transvaal, South Africa, for treating diamond ground. This plant will be in operation sometime in 1950. The Hardinge heavy-media sink-float separator, an adaptation of its counter-current classifier, made its debut on the iron range this past summer. Operators report a high degree of success due to its efficiency and simplicity. More units will be installed for use next year.

Western Machinery Co. is offering a new type "WEMCO Drum" separatory vessel for treating coarse sizes of coal and ore. These separators are available in the sizes from 6 to 14 ft in diameter and from 4 to 12 ft long. The Link-Belt type separatory vessel was adopted by several coal cleaning plants during the past year. The Consolidated Mining & Smelting Co. of Canada put a 10,000-ton-per-day sink-and-float plant into operation at the Sullivan concentrator near Kimberley, B. C. This process uses galena for the heavy medium.

Nelson L. Davis Co. of Chicago is offering the "float and sink precision processor," a modification of the Link-Belt type vessel. This vessel has been installed in some of the largest coal cleaning plants in the United States and also in several plants in Europe. Nelson L. Davis Co. is offering package plants for coal cleaning using heavy-media separation processes with magnetite medium. At least one such plant is already in operation in the United States, and several are under construction both here and abroad.

Southwestern Engineering Co. is supplying their "SWECO" heavy-media package plant for the treatment of ores and coal employing the Akins separatory vessel similar to that which has been in use on the iron range for several years.

Charles Remer of the Charleson Mining Co. reports favorable results with multistage jigging of Mesabi iron ore with a new jig of his design.

Several Humphrey spiral plants went into operation during the year. Of these, the largest was the one erected and now being operated for the Du Pont Co. by the Humphrey people at Starke, Fla. For the treatment of iron ores, additional installations were made on the Mesabi during the year. American Cyanamid at Piney River, Va., installed 24 spirals between the primary and secondary grinding stages. At this plant, the primary purpose is to remove "mud balls" which float through the grinding mills, but which later break up in the reagent conditioners and seriously interfere with flotation. In addition to mud ball removal, considerable concentration takes place.

The Dutch State Mines cyclone processes are attracting a great deal of interest as a means of separating minerals on the basis of specific gravity difference in the size range minus ¼ in. These processes should find big tonnage application in the coal and iron ore fields. This past summer a pilot plant was operated on the Mesabi using a 6 in. diameter cyclone which treated 8 to 10 long tons per hr of minus ¼ in. plus 48 mesh iron ore using magnetite as the medium. Results indicate that a good separation took place at a specific gravity of approximately 3.0 which is over .5 higher specific gravity than can be achieved with magnetite in the heavy-media processes. Detailed metallurgical results are not as yet available, but preliminary reports indicate that the efficiency of separation was better than that achieved by any other process treating iron ores in this size range.

At the Chicago meeting of the American Iron and Steel Institute in October, F. X. Tartaron presented a paper on the beneficiation of northern iron ores. A companion piece on southern ores was presented at the Birmingham meeting of the AISI by E. H. Rose. Both outlined the conditions to be met, which differ markedly between the respective areas, summarized research findings

to date, and appraised the outlook for economic beneficiation of low-grade ores on an extended scale, and the implications thereof.

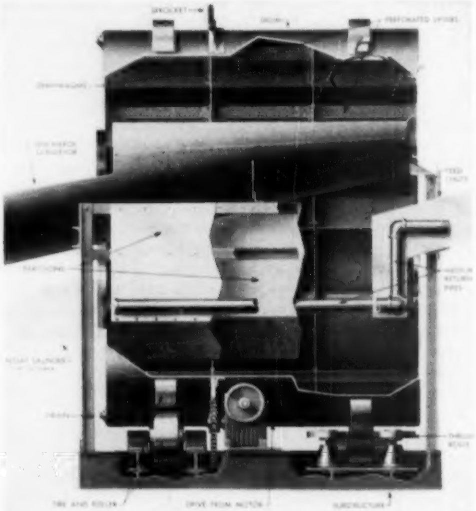
Flotation

At Sweetwater, Tenn., L. A. Wood is about ready to start up a plant to produce 10 tons of barite concentrate per hr. The flow sheet calls for closed circuit grinding in a Hardinge mill, followed by Denver flotation cells. Flotation concentrate will be leached to remove iron.

At Hartwell, Ga., the Funkhouser Corp. has recently put in a gravity concentration plant to recover fine mica from decomposed pegmatites. Essential equipment consists of a Hardinge mill, bowl classifier and Humphrey spirals.

In the field of flotation, a novel method of selectively floating a refractory copper-zinc ore was disclosed at the Columbus Meeting in a paper entitled "Differential Flotation of Sulphurated Copper-Zinc Ores of Prince Leopold Mine" by Piedboeuf and Fortemps of the Union Miniere, Jadotville, Belgian Congo. The Prince Leopold ore has a highly active sphalerite which makes selective flotation of the copper difficult. A primary copper concentrate is produced using cyanide as a depressant. Following this step, bulk copper-zinc concentrate is removed using ethyl xanthate as the promoter in the presence of copper sulphate and lime. This bulk concentrate is then conditioned with ferrocyanide which depresses the copper while the sphalerite floats. Combined copper recovery is 86% in a 29% concentrate. The recovery of zinc is 74% in a 55% product.

Considerable progress has been made in the flotation of oxidized lead ore. The practice at the St. Anthony Mining Co. in Arizona was described by E. V. Given at the meeting of the Arizona Section, Nov. 14. The ore is ground to 44% minus 200 mesh in the presence of 4 lb soda ash. Conditioning time is 15 minutes at 20% solids in the presence of 0.39 lb reagent 425 and 0.63 lb reagent 301. The pH in the conditioning step is maintained at 8.8 to 9.0. A 50-50 mixture of Aerofloat 31 and cresylic acid is added in the amount of 0.3 lb to the first cell of the rougher circuit. Sodium sulphide, 1.8 lb, is added to cells 1, 3, and 5 of the 9-cell Denver rougher machine. The quantities of reagents 425 and 301 are rarely varied. Sodium sulphide and the cresylic acid-Aerofloat 31 are the control reagents, and the operators are allowed to vary them to meet changes in ore. The following assays illustrate the efficiency of this operation.



This Wemco drum separator used for heavy-density separation has large output. It has possibilities for achieving stage separation.

Assays

Oz Gold	Oz Silver	% Copper	% Lead	% Zinc
0.041	0.50	0.37	3.23	2.91
0.655	7.71	2.14	50.52	7.35
0.004	0.07	0.26	0.39	2.65

Recoveries

	Gold	Silver	Copper	Lead	Zinc
Heads	100.00	100.00	100.00	100.00	100.00
Concentrates	90.12	86.56	32.94	88.55	14.28
Tailing	9.88	13.14	67.06	11.45	85.72

From Australia comes news of a novel procedure for the selective flotation of dump material assaying 5.5% lead of which 5.3 is oxidized, 3 oz silver and 3.8% zinc. The flow sheet incorporates flotation of the zinc sulphide first using 16 lb sulphuric acid, 0.5 lb copper sulphate, 0.3 lb ethyl xanthate, and 0.1 lb cresylic acid. The zinc concentrate will assay around 35% zinc and 8% lead. The zinc flotation tailing is then conditioned with 2 lb per ton of P_2S_5 and 1 lb per ton Aerofloat 31 at pH 5. The lead concentrate will assay around 25% lead. Although both the lead and zinc products are low grade, they are marketable. It is maintained that on this dump material P_2S_5 is a more effective sulphidizing agent than any of the more common agents such as sodium sulphide and sodium hydrosulphide.

U. S. Patent 2,482,859 issued in September 1949 to McKenna, Lessles, and Peterson of International Smelting & Refining Co. describes a method of recovering a zinc concentrate from an oxidized zinc ore which comprises subjecting a pulp of the ore to froth flotation in the presence of a soluble compound of an aliphatic amine containing 8 to 18 carbon atoms and about 6 to 12 lb of a soluble sulphide per ton of ore.

There appears to be considerable interest in the flotation of iron ores. Minerals separation pilot flotation plant operated again this season on a small scale test unit basis. Cyanamid's iron flotation process using their "800 Series" reagents has been successfully applied in the laboratory to the concentration of various "iron formations" and it is reported that one plant is in the design stage. These same "800 Series" reagents are also being successfully used to concentrate garnet

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At Broken Hill, New South Wales, lead and zinc are selectively floated in Denver flotation machines equipped with single motor drives.

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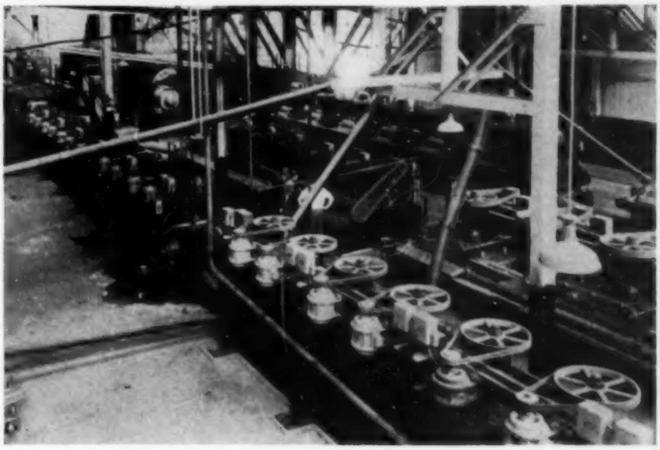


ores in New York State and for the removal of iron-bearing minerals from feldspar and glass sands.

The new mill Quemont Mining Co. started up during the year is now reported to be up to full tonnage and metallurgical efficiency. The ore is quite similar to that of Noranda Mines. C. G. McLachlan was consulting engineer and laid out the flow scheme. A new 4000-ton mill is now being designed to treat the complex, partially oxidized lead-zinc ores of the Zellidja mines in North Africa. General Engineering Co. of Canada are the contractors and F. W. McQuiston, Jr., of Newmont Mining Corp. is consulting metallurgist.

Tennessee Copper Co. has installed several of the new Booth flotation machines and report favorably on their performance.

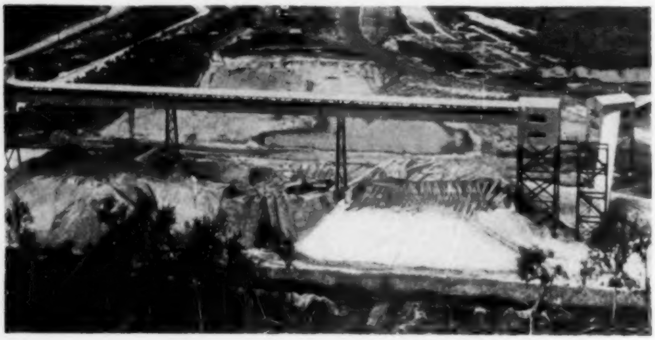
Cyanidation In the field of cyanidation considerable progress has been made on the practical application of charcoal precipitation. Getchell Mine, Red House, Nev., has operated a 200-ton continuous pilot plant using the Pimentel screen for retaining the charcoal in their agitators while advancing the pulp. Highly efficient precipitation with high charcoal loading is reported.

U. S. Patent 2,476,420 to Richard Krebs describes a method for removing loaded charcoal from a cyanide ore pulp by means of screening. A special, hard, abrasion-resistant charcoal, which is coarser than the ore particles, is specified. Byler, U. S. Patent 2,478,652 describes a method of removing gold and silver from loaded activated charcoal by means of ammonia. Crabtree, Chapman, and Winters, in a paper delivered before the AIME Meeting in February 1949, described their process of removing gold and silver from loaded activated charcoal which consists of applying strong cyanide solution under a pressure of approximately 90 psi at a temperature around 300C. The Precious Metals Station of the Bureau of Mines at Reno, Nev., is reported to have developed a process of removing gold and silver from activated charcoal by electrolysis. Charcoal precipitation of gold and silver has been known for many years, but the stumbling block has been the removal of the precious metals from the charcoal and its reuse. Now that several methods have been developed for removing precious metals from the charcoal, the use of charcoal cyanidation for slimy, slow-settling ores will, no doubt, be widely adopted.

N. Hedley of Cyanamid's mineral dressing laboratory has found that polyphosphates such as sodium hexametaphosphate, sodium tetraphosphate, tetrasodium pyrophosphate, and sodium acid pyrophosphate act as "sequestering agents" and thus have a pronounced effect in reducing calcium carbonate deposition on filter cloths and in pipe lines in cyanidation plants. Malcolm Black of Wright-Hargreaves reports that the lime coating on his filters (under the filter cloth) formerly had to be removed with pneumatic hammers. Now this job is done by treating the drum with 25% hydrochloric acid to which has been added an acid inhibitor and an antifoamer. Several other cyanide plants have reported much improved filter-cloth and clarifier-leaf life through the use of these polyphosphates. The amount necessary is small—as little as 0.0025 lb per ton of solution is sufficient.

U. S. Bureau of Mines R. I. 4374 reports the application of ion exchange resins in precipitating gold and silver from pregnant solutions in the cyanidation of the Buckhorn ore, Eureka County, Nev. High efficiency is reported for certain anionic-type resins, but the costs appear to be somewhat high at the present time.

Thickening Little has been published in the past year of interest to ore dressing engineers on the subject of solid-fluid separation. Thickening and filtration appear to be subjects taken for granted by engineers. *Chemical Engineering Progress* has carried several papers showing interest from process angles on the subject of sedimentation as applied to



The conveyor system used at Bartow, Fla., by the International Minerals and Chemical Corp., to carry wet phosphate from the washer and flotation plant to storage, and then to the dryers.

trade waste disposal. The ore dressing fraternity may have to pay more attention to this than in the past if the stream pollution regulations are extended and enforced.

Coal and phosphate operators have been feeling the force of this drive for some time, and new processing plants are being designed with no discharge of waste waters to streams. Water recovery becomes an important factor in many operations so that ponded wastes must be dewatered as thoroughly as feasible. The new Sydney plant of the American Cyanamid Co. features a 300-ft thickener mechanism in a 750-ft basin for this purpose. The new Jones & Laughlin plant at LaBelle, Pa., will employ two 150-ft thickeners in parallel to recover fine coal, the effluent being returned to the washer.

There has been considerable interest shown in a relative newcomer to the field of liquid-solid separations. This is the Dutch State Mines Cyclone. This youngster is versatile; some use him as a separator, others as a concentrating unit, and others as a classification device. With coal people, the emphasis is on its use as a "thickener," ie., maximum removal of fines.

The American Cyanamid Co. has publicized its application in heavy-media separations on the fine fraction, having taken over rights in this area under Dutch State Mines patents and applications.

Dahlstrom presented an excellent paper at the San Francisco meeting analyzing its behavior as a classifier. The Dorr Co. has taken over rights from the Dutch State Mines for all applications except heavy-media. The American Cyanamid Co. will operate ten 4-ft Dutch State Mines cyclones, the largest ever built, in their new phosphate washer at Sydney, Fla. Further experience has been gained in the use of solid bowl centrifuges in the dewatering of fine coal prior to drying.

In the field of gas-solid separations, the most recent development appears to be the Venturi scrubber. Development work continues on the use of high intensity sound waves for agglomerating fine dusts and fumes prior to collection in cyclones. Walter A. Schmidt discusses this and other methods of dust collection in an up-to-date review of the subject in the Nov. 7, 1949 issue of *Chemical Engineering News*.

A dust collecting unit of unique design has recently come from Sweden. It employs a conical unit of light gauge metal with a multiplicity of louvres so pressed that a rippling motion is imparted to that portion of the air stream adjacent to the inner wall. The net component of the several forces set up is inward so that, it is claimed, the solid particles do not touch the wall and only clean air escapes through the louvres despite the opening being many times larger than the dust particles. The solids are withdrawn at the small end of the cone in the form of a highly concentrated dust.

Conveyors

Giant high-lift belt conveyors, king-sized plant feed blending bins, highly developed pump controls, and extensive plant service facilities for on-shift maintenance highlight the 1949 materials handling picture. Important, but less spectacular, are the advances in screen dewatering and feed classification for gravity concentrating devices. Considered by industries, the coal boys take the 1949 prize of the big "E" for effort in materials handling.

The big single-run belt conveyors on the Minnesota range have gone through several years of breaking in, but the steel cord belts still ripple and bow from unequal tensioning of the internal cables during manufacture. All these long belts, save one, need and use steering idlers operating against the edges of the belt. Belt wandering of the 900-hp 730-ft lift belt at a captive Alabama coal mine is limited by photocell-gearmotor circuits that swivel the steering idlers. The same mine is experimenting with the idea of a chevron-type idler to eliminate the swivel troubles.

All steel-cord belt users are learning that cover cuts need prompt repair to prevent rusting of cables and serious belt damage up to, and including, pulled apart belt splices.

More conveyor idler people are looking at sealed-for-life bearings as a corrective for overlubricating tendencies. Some big operators are

adopting idlers with wider-than-normal center rolls to get flatter belt troughing, higher capacity, better training, more uniform cover wear, and less spillage. Stainless steel conveyor belting is still not ready for use by average operators, but synthetic fiber and new cotton belt fabrics are being well received within their tension limits. The biggest captive coal company continues to shine in the field of long belt life and high tonnage per belt.

The large stripping conveyors on the Mesabi make free use of extensible rail-mounted frames and cat-mounted stackers. One plant uses a neat vibrating screen-type suspension under the belt loading point steelwork to cushion the impact of big pieces.

The phosphate industry is talking of abandoning pump transportation of raw matrix in favor of belt conveying, but the project has not gone beyond the discussion stage. High capital cost is a deterrent.

Three high-tonnage coal plants (Pennsylvania, West Virginia, Alabama) have gone to gigantic pocket-type blending bins to put uniformly sized feed into the preparation flow sheet and to even out mine-run irregularities. All ore dressers plagued with plant feed variables might do well to take a look at these bins after they have been operated for a time and operating techniques have been developed. The big iron ore blending plant near Birmingham continues to justify its keep by leveling out mine-run irregularities, too.

Pumping Gone is the day when a pump's speed could not be regulated automatically to accommodate variable feeds. Thanks to some fancy engineering by a prominent sand-pump salesman, standard controls and hydraulics from other fields have been adapted to make a sand pump speed up or slow down as the load varies.

A novel adaptation of mechanical design to permit the use of a superior but previously inapplicable alloy is illustrated in a new rock and gravel pump which has been in successful operation at the LaGarde gravel pit near Anniston, Ala., for the past year. This pump is made of NiHard of minimum hardness of 550 Brinell. Against a total head of 140 ft, the pump is able to transport in one stage a mixture of sand, gravel, and occasional boulders up to 6 in. in size at the rate of 175 tons of solids per hr. The nonductile NiHard, normally vulnerable to severe impact shock, is effectively protected by a backing chamber of confined clear water connected into the gland water system. Wearing-part life has been found to be approximately four times that of manganese in the same service, with a correspondingly slower loss of pump efficiency as a function of wear.

Two sizes of a new rotary pulp distributor that can vary the number of splits without interruption of flow were developed down South for a new coal plant with 64 tables so that feed could be shut off on any table or table section without stopping the rest—all to provide on-shift maintenance without serious loss of tonnage.

NiHard castings in pulp lines and for victaulic pipe elbows are helping the abrasive wear problem in northern New York.

The big word in screening is dewatering fines on mechanical vibrating screens fitted with fine stainless surface. To avoid cloth failure from fatigue, extremely high cloth tensions are used on panels fitted with special reinforced hook strips. One outfit is dewatering minus 14-mesh coal on such a rig and adding flotation concentrate as a second layer on top of the 14-mesh cake. Results reported are good enough to justify abandoning vacuum filtration.

The oversize hindered settling classifiers installed in a table plant in western Pennsylvania, are reported doing a good job.

Now that three-shift operation in coal preparation plants has been demonstrated as economically feasible, the operators have attacked the problem of minimizing overtime maintenance by providing spare parallel equipment as part of an initial installation. Service crane facilities are provided over all equipment too heavy to manhandle. One of these new plants is so designed that wash-down hoses can be turned on nearly everything in the building for cleanup.

Three other interesting new wrinkles in materials handling that have come to my attention are: the use of metallizing to apply long-wearing, anticorrosion, stainless-steel type coverings on conveyor rolls, with good results to date; binhopper sections of short-pitch apron feeders to minimize hang-ups from sticky ore; and a new wobbler-roll grizzly, using meshing elliptical rolls for "peanut butter" or paint-rock ores. This unit acts as a feeder as well as a grizzly.

In the field of pyrometallurgy as it concerns the mineral dresser, "making big ones out of little ones" is the big problem that faces the taconite program. The Aurora plant of the Erie Mining Co. (Pickands Mather) continued operation last summer. The process used was very similar to that described by H. K. Martin at a session of the Blast Furnace, Coke Oven, and Raw Materials Committee in Pittsburgh in April 1948. The Aurora plant will give the mineral dresser a preview of what will be involved in the treatment of magnetic taconites. The final magnetite concentrate assaying 63 to 65% iron and around 8% silica is formed into balls or pellets by the addition of the right amount of moisture. The balling machine looks very much like a short rotary kiln. The balls are then charged into a shaft-type furnace where they are heated to 1100C. The operation of the furnace is continuous, the moist balls are charged in the top and the finished fired balls are continually removed from the bottom. It is reported that these balls or pellets make excellent blast-furnace feed having reducibility at least as high as Old Range ores. Further experiments with taconite concentration and agglomeration will be conducted at the Aurora plant during the coming season.

The Reserve Mining Co. and its associated companies also conducted agglomerating experiments on iron ore at Ashland, Ky., last summer; also Bethlehem Steel Co. at Lebanon, Pa. Details are not yet available, but the reports are favorable.

Fluo-Solids

Dorr Company's "fluo-solids" process is getting a big play. Its advantages over other roasting processes are claimed to be more exact temperature control, better control of gas composition, lower capital and operating costs. Two gold mining companies in Canada, Cochenour-Willans and Campbell Red Lake, are using the fluo-solids process for roasting gold-bearing arsenopyrite concentrates ahead of cyanidation. Golden Cycle Corp. has decided to use fluo-solids roasting in their new mill at Cripple Creek instead of the Edwards furnaces which they operated for so many years at Colorado Springs. Reports from the iron ore beneficiators indicate that reduction roasting with fluo-solids followed by magnetic concentration may be one of the answers to the beneficiation of taconites and other low-grade iron ores.

The process has also been applied to nonmetallics. New England Lime is operating a 100-ton-a-day installation up in northern Connecticut. Fluo-solids is also being used to calcine a hydrated product to the oxide form. A principal consideration in influencing this installation was purity of the final product. Capital investment and fuel costs also entered into the decision.

Hydrometallurgists will be interested to know that fluo-solids, when applied to the roasting of a copper concentrate, will render 99% of the copper soluble. When roasting zinc concentrates, less ferrite is formed.

"FluoDry" is the latest modification of the fluo-solids process to be reported by Dorr engineers. It air sizes and drys at the same time.

Automatic Controls

An increasing amount of interest is being shown in the use of operating control instrumentation and automatic control systems. In recognition of the potential advantages of wider use of these tools to mineral processors, the Minerals Beneficiation Division established a Unit Process Committee in 1949 to deal with the subject, and devoted an entire technical session to it at the Columbus Meeting.

Marquardt, at Combined Metals Reduction Co., is making progressive developments in control instrumentation to help overcome the operating difficulties met with in custom milling as many as fourteen different ores. His electronic manometer at Pioche gives an improved density measurement, and is used for multiple recording of pulp density at various points in the mills. Automatic measurement and recording of pH at six points in the lead, zinc, and iron flotation circuits is practiced to point up immediately any significant changes in ore. It also enables the operators to discern and correct oscillations in lime alkalinity arising through feed-back of middlings and the bad effects of reagent pyramiding (*Mining Congress Journal*, June 1949, p. 33-37). Another automatic device spots and marks the location of a piece of tramp iron buried in the ore bed on a conveyor belt.

Continued advance in instrumental control of grinding circuits is being made. Although it is apparent that the measured variables must be something more than classifier rake load and overflow gravity to achieve full automatic control, improvements in the grinding operation are reported at Sunshine (*Engineering and Mining Journal*, November 1949, p. 107) by use of automatic density control on the classifiers, which operates to vary the dilution water, and by a control on the ball-mill feeder which operates according to the power input to the rakes. Automatic control of the grinding circuit at Castle Dome is smoothing out irregularities in an impressive way. This control is described in a forthcoming AIME technical paper.

Hardinge has brought out an improved "electric ear" with a different circuit and control. Operators report its use has further increased mill capacity. When used in a wet-grinding circuit, pulp density is maintained constant, and in dry-grinding mills, fineness is maintained within close limits. Its greatest use is where labor turnover is high and feed conditions are bad.

J. J. Bean reports that in developing a density recording and control system for heavy-media separation units in the American Cyanamid laboratory, the greatest difficulty encountered was in getting absolutely air-tight connections in the bubble-pipe system. Only copper tubing with sweated joints proved satisfactory. F. M. Lewis suggests that a better record of a classifier operation will be obtained if two bubble-pipes are used, one submerged to some depth in the pool, so that the loading and unloading of the machine can be observed. Also, a record of the density of the cleaner tails in a closed flotation circuit will help in coordinating shift operations, as it will show an increasing tenor in the circulating load.

The attention of mineral dressing engineers was called by Keyes and Dorenfeld to the advantages of statistical control methods for controlling and improving the quality of a milling operation. A practical application of statistical quality-control methods to mineral processing develops control charts on significant variables by which trouble in a plant can be tracked to its cause and corrected, so that final product variability is held within preset limits. In applying statistical methods, the usual mill assays and metallurgical operating data are used.

Taggart points out that statistical quality control constitutes a simple arithmetical method of making more certain and more complete use of these data, yielding a reasonably dependable basis for the design of changes in equipment and operation. Hassialis, who has used statistical control methods with much success in industrial work, reminds us that quality control does nothing which is essentially new but, unlike the rare engineer gifted with the capacity to diagnose a complicated engineering situation and arrive at a valid conclusion in a remarkably short time by inspired guesswork, quality control achieves the same results by systematic and orderly procedure.

An informative and suggestive series of articles during the year by Setter of General Electric (*Engineering and Mining Journal*, April 1949, p. 75-79; June 1949, p. 72-75) points out many examples of the use of electronics for achieving automatic control and will suggest applications to mineral processors.

Four million tons of solids are dewatered each year by these two 225 ft. Dorr Torq Thickeners at the Castle Dome Copper Co's. Miami, Ariz., operation. In the left foreground a hydroseparator removes coarse oversize from flotation tailings.

An example of the importance of instrumentation and process control in the processing of raw minerals is given by Jorge Garibay, who points out (*Industrial Engineering Chemistry*, July 1949, p. 1338-40) that the continuous system of processing phosphate rock to manufacture superphosphate is made possible only through the use of automatic control on material flow. A system of cascading control instruments to achieve the continuous proportioning of flow of phosphate rock, sulphuric acid, and water is described.

Some of the factors which must be evaluated in order to determine what use might profitably be made of process instrumentation and control in any specific mineral processing plant, are discussed by Byler (*Mining Congress Journal*, September 1949, p. 22-24).

Pyrolysis and Agglomeration

The extent to which iron ore beneficiation has been practiced in the past and its importance to blast-furnace operations has not been generally realized. Due to the rapid depletion of the high-grade Mesabi Range ores and the high-quality coking coals, together with the increases in costs of these raw materials and labor costs, the iron and steel producers realize that beneficiation of blast-furnace raw materials will, in the future, present more opportunities for reducing costs than any other operation involved in the manufacture of iron and steel.

The desirability of beneficiation has been appreciated by most blast-furnace operators, but it has not been appreciated by company management until the rapid rise in the costs of raw materials and labor made it almost imperative to do something to decrease the cost of pig iron.

The pelletizing process for agglomerating very fine magnetite concentrates has passed out of the laboratory stage, and, at the present time, two large pilot plants are in operation. Inasmuch as it is very difficult to definitely ascertain from laboratory tests the functioning of special items of equipment and the necessary operating techniques for a commercial size plant, some difficulties have been encountered in the pilot plant operations but nothing sufficiently serious as to impede the progress of this work or to indicate it will be commercially unsuccessful. Considerable interest is shown in this process as it has been developed primarily for use in connection with the utilization of the low-grade ores of Minnesota.

Briquetting has not been adopted to any large degree at this time by the steel industry for agglomerating fine iron ores. One commercial plant has been built this year for briquetting flue dust, and several other plants are contemplated. Considerable interest has been shown in this process by several of the steel companies, and favorable reports on this method of agglomerating fine iron ore may be expected in the near future.

The nodulizing process has not yet been adopted in this country for agglomerating fine iron ores, but this method may come to the fore in the near future. At the present time, however, there is one rotary kiln plant operating on manganese ore. During World War II, nodulizing of iron ore was carried on to an appreciable extent by the cement industry, which furnished considerable information of value. As a result of this, the nodulizing process may attain the position in iron ore beneficiation that it held previous to the development of the sintering process.

In the writer's opinion, the year 1949 has shown rapid progress in the beneficiation of raw materials, and this progress is only the start of an intensive program that covers the ferrous and nonferrous industries. At no time in history has management given more thought to the beneficiation of raw materials than it has in the past few years, and it may be expected that as a result large investments in beneficiation plants will be made in the near future.

Open-Pit Mining on the Iron Ranges—1949

by Grover J. Holt

Open-pit mining on the iron range has been in a stage of transition for several years from the standpoint of mechanization. The most radical change in open-pit mining methods was started in open-pit haulage in 1937 with the departure from the then standard system of locomotive and car transportation and the advent of the heavy duty truck as a replacement. The initial use of trucks was followed shortly by the first installation of a conveyor belt for open-pit ore haulage. The growth of the combination of trucks for gathering units delivering to a conveyor system for transportation out of the pit, has been rapid and this transition appears to have reached a peak in 1949 with locomotives and cars now being used in only a few of the largest open pits.

One point which must be considered, if we assume that the maximum equipment changeover point has been reached, is that the largest pits have probably passed their peak of production. Future ore replacement must come from smaller pits wherein the truck conveyor system has done an outstanding job.

Drilling

Drilling of both overburden and ore prior to blasting is largely done at present by churn drilling. The process of jet piercing of 6 to 8-in. blastholes has been tested during the year in the mining of taconite formation. Jet piercing utilizes mixtures of oxygen and fuel oil for the production of high

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rock temperatures at the point of impingement of the flame, followed by water quenching to provide a spalling action in the rock. The water converted to high pressure steam provides the force necessary to clean the hole and blow the spallings to the surface.

The latest model jet piercing rig is mounted on caterpillar treads and appears well adapted to heavy-duty use. A smaller piercing rig for manual handling in blockholing was tested on the iron range during the year.

A heavy-duty piston drill, equipped with a $5\frac{1}{2}$-in. tungsten-carbide insert bit, was also being subjected to tests in 1949. This rig is self-contained, having the necessary compressors, mast, etc. mounted on a caterpillar base.

Drilling for the purpose of sampling concentratable ores is accomplished by structural drilling, which was inaugurated on the iron range. In structure drilling the ordinary churn drill bit

Although larger pits like the Hull-Rust mine (right) still use rail haulage, smaller operations are finding truck haulage more adaptable to their size and needs.

Smaller truck pits have replaced these large rail haulage pits.

is replaced by a pipe having a hard-surfaced bottom edge which breaks comparatively large particles of ore and waste loose from the mass. The hole is cased to the bottom, and by pumping water down between the casing and the pipe bit, these particles are washed up through the pipe bit to prevent the sample from being pulverized in the hole. This provides a relatively coarse sample for testing concentration methods in the laboratory. In some cases, these structural drill holes are later used for blastholes. Blasting is conducted in conventional manner by standard dynamite charges, using primacord or electric detonation.

Loading

Shovel loading of ore and stripping is done mainly by electric shovels having from 4-cu yd to 7-cu yd bucket capacities. Smaller shovels are used for cleanup and auxiliary loading. These smaller type machines are being subjected to testing to improve their operating characteristics, especially in the Diesel type of machine. One of the mining companies has installed a torque converter on a 2½-cu yd machine, which is a development worth watching. The report on this unit is quoted verbatim:

"A six cylinder Diesel engine rated to develop 170 hp at 900 rpm was removed from a 2½-cu yd Diesel shovel and in its place was put an automotive-type Diesel engine rated to develop 243 hp at 1600 rpm, driving through a 17-in. torque convertor. The cost of the automotive type-engine and the torque convertor, plus installation charges, was slightly greater than the original cost of the heavier, slower speed Diesel engine.

"The shovel operating speed was increased materially. While it is too early to make any definite statement as to the increased output that can be obtained from such an installation, because the shovel has not worked 60 days since the change was made, it seems safe to predict about 10% greater output."

On the iron ranges, it frequently becomes necessary to move electric shovels, too large to be hauled on trailer units, from one open pit to another. These moves may involve distances of several miles and could ordinarily be made by the shovel under its own power only where transmission lines could be followed. A tremendous amount of shifting of transformers, cables, etc., was involved under the old method. However, an ingenious system has been devised to furnish the necessary current from a Diesel-driven generator mounted on a truck which travels with the shovel. A description of the power unit and method of handling is given below:

"This set consists of a 250-hp truck-type Diesel engine running at 1800 rpm direct connected to a 110-kw, 250 v d-c shovel-type generator and a 125 v, 96 amp, d-c exciter generator. When in use this generating set is mounted on an old 30-ton ore haulage truck with box removed.

"When the shovel is to be moved, the dipper and dipper handle are removed and the boom is

lowered so that the boom point sheave is lower than the top of the A-frame. The leads from the generating set are connected directly to the hoist-motor leads by quick connectors. The truck with the set follows behind the shovel at a distance of about 30 feet.

"Nine men are required to move a shovel using the truck-mounted generating set for power supply, whereas twenty men were formerly required to make a long move with a shovel when

Moving this shovel with power from the Diesel generator set on the truck saves time and men.

power was supplied by means of a cable. The make-up of these crews is as follows:

Move by Generating Set	Move by Cable
1—shovel engineer	1—shovel engineer
1—tractor operator	1—tractor operator
1—maint. mechanic	1—maint. mechanic
1—service truck driver	1—service truck driver
2—electricians	3—electricians
1—shovel engnr., maint. boss	1—shovel engineer, maint. boss
1—heavy duty truck driver	12—general laborers
1—automotive mech.	
—	—
9—Total	20—Total

"A tractor is needed to help the shovel climb the steeper grades encountered and to hold it back when descending long steep grades. Electric shovels ranging in size from $2\frac{1}{2}$ to 6-yd have moved by this means for distances up to 8 miles. About 4 miles can be accomplished in an 8-hr shift if no difficulty is encountered."

It appears that the dragline is coming into its own field in stripping projects on the iron ranges. There are at least 4 draglines in stripping service, the largest handling a 25 to 30-cu yd bucket and the other three ranging from 8 to 10-cu yd capacity. The largest unit and one of the smaller units are loading belt-conveyor systems through portable screening plants, while the other two smaller units are used for truck loading. Other combination dragline and conveyor systems for stripping disposal are being planned.

It is reported that the hydraulic dredging jobs at Crosby, Minn. is nearing completion and will be followed by shovel cleanup looking forward to ore production. Dredging has been resorted to for some time by Steep Rock Iron Mines, Ltd., in Canada for the removal of lake-bed silt; however this is the first time dredging has been resorted to on the American side of the border for stripping lake-bed material in iron mining.

The transportation of material in open-pit work, making up one of the largest individual items of production cost in the past, has been the object of much study and the greatest changes have been made in transportation equipment. Where locomotives and cars are still being used, steam has given way to Diesel power. Few steam locomotives remain in service and no changes have been noted in cars, the 30-cu yd side dump type now being favored.

Trucks

While trucks when originally installed were used for all pit transportation of ore and stripping, the bulk of the lift from the pit floor to surface has now been delegated to belt conveyors, retaining the trucks as gathering units shuttling between the shovel and the belt loading pocket. The major portion of stripping transportation is delegated to trucks, all stripping in freezing weather being handled in this manner although the drag line-conveyor combination appears certain to make inroads on truck transportation of stripping in the milder months of the year.

There has been a increase in truck transportation since 1941 when only about 100 heavy-duty trucks were in operation, to the present time, when, for the year of 1949, about 700 such units were in use. The original trucks handled an average pay load of 15 tons whereas in 1949 the major portion of the truck fleets was made up of 20-ton units with a substantial number of 30-ton trucks.

Several 30 and 40-ton trucks of end-dump and trailer types as well as a Tourneau rocker are under test in the iron country. The result of these tests may affect the load carrying capacity of haulage units for the future.

In the truck field it appears that the torque convertor may be called "Miss Mesabi of 1949." A great many units have been installed on trucks during the past year and improved operating results are reported. In addition to the torque convertor test mentioned above on a Diesel shovel and on truck units, a late crawler type of tractor has been equipped with a torque convertor and favorable results are reported. Another year may be necessary before final judgment is passed on the results of the torque convertor, but favorable results are indicated.

The trend in truck bodies is toward the exhaust-heated type which makes unnecessary the use of salt, chloride, or other means to prevent freezing. The heated body appears to work well on sticky dirt by drying out a thin layer of material next to the steel body, thus preventing caking and lodging in the corners and valleys of the truck body.

Conveyors

Belt-conveyor transportation has come a long way since 1941 when only 6 belt conveyor installations, having an aggregate length of 9,110 feet, were used in open-pit mines on the iron ranges. In 1949 there were 26 conveyors, having an aggregate length of 32,965 feet, transporting ore from the pit floor to surface. In addition, in 1949 there were two conveyor systems transporting stripping from the pits to the dumps having an aggregate length of 13,851 feet.

A summary of available data shows the fol-

lowing comparison between working installations in 1941 and 1949:

	1941	1949	Increase 1949 over 1941
Number of conveyor installations	6	28	433%
Total length of conveyors used	9110	46816	514%

A list of the 1949 conveyor installations used in transportation in open pits is given in detail below:

TABLE I

Conveyor Belts Delivering Iron Ore From Pit Bottom To Washing Plant or Railroad Loading Bin on Surface

Mines	Width of Belt (in.)	Total Conveyor Length (ft.)	Total Conveyor Lift (ft.)	Number of Flites	Belt Speed
Arcturus	30	1050	160	2	500
Canisteo	36	936	271	3	500
Embarrass	36	1671	333	3	515-575-590
Fayal Annex	30	997	184	3	500
Galbraith	30	900	187	2	500
Gilbert	30	405	72	1	500
Gross Marble	30	1106	257	1	500
Harrison	30	962	205	3	500
Hawkins	30	1081	264	2	550
Hill Annex	36	1331	310	3	550
Hill Nelson	30	1544	382	1	500
Hill Trumbull	36	3228	293	5	400-530
Holman	30	1782	372	2	550
Holman Tailing Basin	24	1300	40	3	400
Kevin	30	3400	167	2	550
Mississippi	36	476	136	2	500
Mountain Iron	30	845	54	1	500
Perry	30	970	227	1	550
Portsmouth	30	1750	260	1	550
St. Paul	30	852	274	3	500
Scranton	30	1622	352	1	593
Section 18	30	452	112	1	530
South Agnew	30	1032	49	1	500
Susquehanna	30	835	99	2	500
Webb	30	1000	300	3	400
Weggum	30	1438	237	3	500
Total length 26 installations		32,965			
Conveyor Belts Delivering Stripping From Pit to Stripping Dump					
Canisteo	36	6151	227	7	550
South Agnew	48	7700	250	8	550
Total length 2 installations		13,851			
Grand total length of all open-pit conveyors on ore and stripping service		46,816			

In addition to the above installations, several long conveyors have been installed and abandoned since 1941, due to exhaustion of ore available for belt transportation. Such was the case at the Morriss, Mesaba Mountain, Schley, Atkins and other open pits. Those installations would in the aggregate be about equal to the total length of conveyor used in 1941, which gives a better indication of the increasing use of conveyors in open-pit work.

Typical of the types of equipment used in the smaller pits are this shovel and the 20-ton Euclid.

It is apparent that the 30 in. wide conveyor belt operated at speeds of from 500 to 550 fpm is the most popular combination for open-pit ore work. Most of the 36-in. belts have been installed where wet or chunky ore had been contemplated prior to installation. Most of the ore handled on these belts has been reduced to a maximum of 4 to 6 in. in size by a combination of screening and crushing or by screening and rejecting the oversize.

For the shorter belts with a low lift, ordinary duck-type belts are used but in the installations where long flights with high lifts are contemplated, cotton or rayon cord as well as special flexible-fabric belts are used to maintain flexibility in troughing and yet provide safety factors for high belt tensions. In case of extreme length and lifts, steel cord belts have been installed.

Very satisfactory belt life of from 5 to 10 million tons or more has been attained or is expected from present installations. Proper design of transfer points and adequate belt maintenance has aided in extending belt life. Today almost every operating company maintains its own vulcanizing crews with equipment to care for cover and carcass cuts to prevent deterioration. Equipment repair departments are also maintained to extend the life of idlers and mechanical equipment.

Satisfactory belt cleaning has and will always be a problem. One of the early belt installations on the ranges utilized a water spray below the head pulley followed by a rubber wiper, which has proven to be the most efficient type. It is reported that one firm is considering the possibility of twisting the belt 180 degrees as it leaves the bottom of the head pulley, thus laying the belt top side up on the head snub pulley as well as the return idlers. This would be repeated as the belt leaves the foot snub pulley with the

belt righting itself as it contacts the foot pulley. If this system works out, any buildup on return idlers should be minimized. It is stated that heavy flat-power transmission drive belts are thus twisted without undue stress on the belt. This system has not been installed but is a development worth following.

Spacing of troughing idlers is undergoing change on the long haul belts. The troughing idlers are spaced at 2½ ft centers at the lower end, where belt tension is low, to avoid sag between idlers. At the upper end of the conveyors a spacing of 4 ft centers is maintained where belt tension is high and less tendency to sag is encountered. Idler spacing is increased in regular segments of the belt using increased spacing of 3 or 6 in. on each succeeding segment from the bottom of the conveyor to the top. Several of the conveyors listed above maintain the varied center-to-center spacing of troughing idlers.

Antifriction bearings are generally used throughout idlers and pulleys. Drives are usually direct connected from motors to reducers to head shafts. These drives are ordinarily of the single type but in long-haul, high-lift installations, dual or tandem drives are used. Due to the possibility of accident or power failure, backstop protection is provided, usually of the magnetic-thrustor type either on the head shaft or on the reducer high-speed shaft. On the long haul, high-lift installations double protection is usually provided in the form of both magnetic thrustor and mechanical hold-back types. The countershaft drive and ratchet type of hold-back is seldom used.

Conveyor galleries have been redesigned to eliminate much of the heavy steel and many of the installations provide box truss sections from 30 to 40 ft between supports as the main supporting members.

This truss is made up of light angle members and the plank walk-way is supported by heavier angles bolted to the lower chords of the truss. Gallery side and roof sheeting is supported by bolting upright angles on both sides of the truss and one upright angle at the end of the walkway members. Timber purlius, (2 by 4 in.) are bolted to these uprights and the corrugated sheeting providing closure on the roof and two sides nailed to the purlius. This type of gallery has proven satisfactory from both capital investment and maintenance standpoints.

At the truck dumping point over the pit, screening plant retractable treads are prpvided over the truck dumping hopper to provide a driveover arrangement and eliminate the time lost in backing up to dump, as was the case in the original layouts. After the truck has passed over the hopper, the treads are retracted by air cylinders to provide an open top hopper into which the load is dumped.

Most of the feeders under these truck hoppers are built up of manganese steel including pans, pins, bushings, rollers, chain and most of the moving parts. Other alloys are being tested for certain parts of these feeders. The feeder load is dropped on heavy-duty vibrating screens for elimination of the plus 4 to 6 in. rock which may or may not be crushed. In case the rock is wasted, trucks haul the oversize to rock dumps or if crushed, the product joins the screen undersize on the belt. Most installations provide a secondary feeder for screen undersize to smooth out the load to the conveyor.

In many cases the conveyor transports the ore direct to a washing plant on surface or to a surge pile from which it is withdrawn to feed the washing plant. Where the ultimate delivery is to railroad cars, the conveyor usually drops its load into a loading bin provided with air-operated gates for car loading.

The most recent departure from conveyor belt transportation of iron ore in open-pit practice utilizes skips of 20-ton capacity hoisted up a 38-degree slope in counter balance. The skips have been specially designed to eliminate dead weight and are carried in a car to provide a rock-over dumping action. Each skip will hold a truck load of ore to synchronize hoisting and hauling operations. In this case the ultimate length of skipway is expected to exceed 800 ft and the skip method of hoisting eliminates excess stripping for conveyor benches and provides a ready method of lowering the truck dumping point. Other pits have used the skip hoist method in the past but most of these predated the advent of open-pit conveyor systems.

Auxiliary open-pit equipment has followed the change in pit lining and transportation methods. Light and heavy duty cranes, road graders, tractors, drilling equipment and various maintenance equipment are mounted on rubber tires or caterpillar treads for mobility.

It is a safe prediction that each year in the future will find new types of equipment being fitted into the mechanization plan. With these changes come the necessity of closer coordination of supervision, as is witnessed by a new system of communication set up by one of the mining companies. A report on this promising method of closer contact, utilizing two-way radio communication, is quoted: "This type of communication has recently been installed to provide faster communication between the supervisory force and different parts of the mine and to eliminate the necessity of building long telephone lines to remote parts of the mine or waste dumps and then having to move them constantly.

"At present this installation consists of a broadcasting station and six portable two-way radio sets. Three of these sets are installed in automobiles used by the superintendents and general pit foreman; the other three sets will be located on waste dumps or at other parts of the mine where no telephones are available. This system has been in operation less than two weeks, but so far has proved satisfactory."

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Beneficiation on the Range

by L. J. Erck

HEAVY-MEDIA separation continues to be the favored process for concentrating the coarser fractions by elimination of undesirable tailing and middling fractions. The first vessel used for heavy-media separation was the closed-top cone. Further developments then led to the Akins spiral separator which fulfilled the requirements for improving metallurgical separation as well as gaining mechanical advantages. During the last season there has been a substantial influx of separator designs for further improvements of metallurgical separation based on the heavy-media method as well as attempting to garner further mechanical advantages with reduction in power consumption to boot. The newest of these designs was the Hardinge counter-current separator which was introduced into the field last spring in two plants. Both Hardinge separators proved satisfactory in operation and substantiat-

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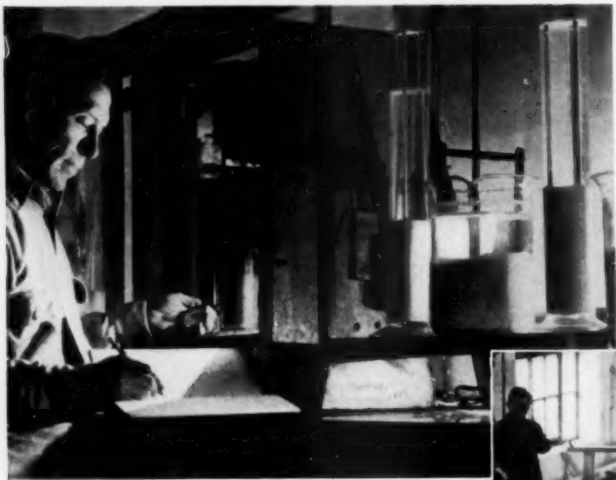
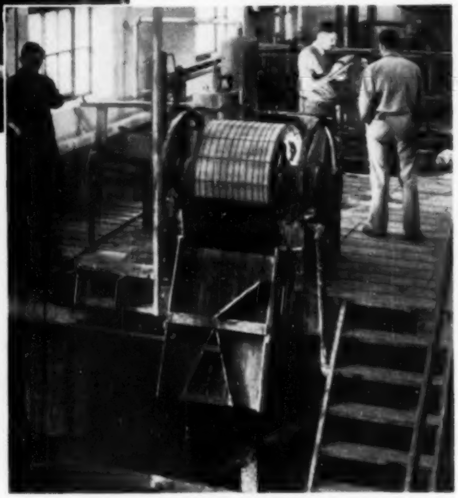


Research in action—settling tests in tubes provided with a stirring device, and, (below) a semi-works scale demonstration involving the use of a rotary vacuum filter. Both at the Dorr Co.'s Westport Mill.



ed the findings of the original laboratory work using smaller models. The Western Machinery Co. has developed a drum-type separator, one of which was installed in a plant on the Cuyuna Range. Unfortunately, the strike shut down this project just about the time the operating difficulties were being overcome and, therefore, it was impossible to obtain conclusive data. This means that the project will have to be postponed until next spring when the operation will resume.

Several other types of drum separators have been proposed by other companies, but to date none has been tried commercially as far as the Mesabi Range is concerned. The mechanics of heavy-media separation have proven interesting during the past two years, and the interest shown by manufacturers will lead to improvements.

Mobile plants have been introduced and are being used primarily by the smaller operators. These units make it possible to work properties which heretofore had been abandoned because the crude materials could not be adequately concentrated by the simple, straight-wash flow sheet employing screening and classification. These units are simple, compact plants which are relatively easy to operate. For the most part the mobile units are equipped with open-top cones and consideration is being given to replacing the cone with the Akins spiral separator or the drum-type separator.

Jig Plants. — At the present time, there are two plants operating with jigs for concentration. One plant is working on pit crudes and the other operating on a lean ore stock pile. The jig in this instance was designed by the personnel of the mining company operating this property. The design is somewhat novel and has attracted attention on the Mesabi Range. It was designed for the immediate purpose of treating the lean ore contained in the stock pile. Comparative tests would indicate that this is one instance in which jigging offers some advantages in concentration over that of heavy-media separation. In general, however, the trend has been away from jigging operations.

Fine Ore Separation. — Ways and means of concentrating what is known as fine ores for the Mesabi continues to be a problem at the writing of this article. Several methods have been developed both in the laboratory as well as in pilot-plant operation which give some encouragement. It is a well-known fact that it is possible to make clear-cut separations by one of several ways, but the mechanics become somewhat involved. Fine ore is generally defined among the operators to mean classifier product or sizes below those which can be adequately treated by heavy media. The upper size limit of this product will vary from ¼ to ⅛ in. depending upon the individual practice. Up to now there has been a general "spearing around" to find a stopgap for treating these fines until such time as a positive method can be developed. Present means of concentration involve straight classification, abrasion milling followed by classification, abrasion milling followed by Humphrey spiral concentration and jigging. The horizons encountered in some cases have become such that hydraulic means are no

longer proving adequate. This same problem is likewise aggravated by the fact that concentration of the coarser fraction will no longer produce a concentrate which when mixed with the fines will produce an over-all grade product. In other words, the concentrate from heavy media on the leaner horizons is usually limited in silica and, therefore, concentration of the fines will have to produce an equivalent concentrate in grade.

The Dutch State cyclone has recently been introduced to the Mesabi and is being studied to determine how effective it is in concentration. A pilot installation was operating during the last season using the full complement of equipment to complete the flow sheet. Results obtained from this operation were for the most part favorable. Mechanically speaking, there are still some problems to work out, such as screening and recovery of the media with magnetic separators. Free-separating ores, or those containing a minimum of interfering middling product, produce the highest grade concentrate, as the separation can be made with a lower specific gravity. On the other hand, those ores containing a substantial quantity of middling offer some resistance to separation at higher gravities where an interference by viscosity is met. Several laboratories have made cycone installations and although the reports of such work are favorable, it is too early to say definitely whether or not the mechanics involved can be applied to the problems. The Dutch State cyclone, in this case, employs fine magnetite as a media using a variation of the conventional magnetic-cleaning circuit such as is found in the heavy-media plants in treating the coarser fractions.

There are other developments along this line using other receptacles and making separations by heavy media. Here likewise there has not been enough work performed to make any definite statements, but the initial results show promise. From time to time notes are compared by the various companies in order to determine whether there is some parallelism in the work, so that the research engineers may know whether or not they are on the right track.

Abrasion milling is still being used in three plants. Two of these operations involve abrasion milling followed by classification, and one abrasion milling followed by spiral concentration. In general, abrasion milling appears to offer a definite advantage, particularly on those ores which contain an abundance of interfering middling.

Classifier Overflows. — For the most part, the classifier overflow from the Mesabi plants is directed to the tailing pond where the material is stored for future treatment. Several plants have installed Dorrco sizers for treating these overflows and thereby find it possible to obtain partial recoveries on this material. The Dorrco sizer is limited, however, as to the size range that can be effectively handled and some iron goes to tailing. An installation has been made for trial next year which will use a combination of Humphrey spiral and Dorrco sizer for treating the classifier overflow. In this case, the classifier overflow contains considerable silica in the coarser fraction. If such material was to be treated by the sizer alone, the coarse silica would have to be absorbed in the concentrate. It is anticipated that by running the fines through the spirals first, the coarse silica will be eliminated and the rougher concentrate produced by the spirals will then be passed through the sizer for further treatment.

Future Installations. — Two additional heavy-media units should be in operation on the Mesabi Range next season. One of these will be on a property which for many years operated primarily on wash ores. The heavy-media unit should prove beneficial in extending the reserves of this mine. The fine ores in this plant will for the time being be treated by abrasion milling and classification with spiral concentration for the classifier overflow.

The second heavy-media installation will also be made on a property which heretofore has been classified as a wash ore. In this case, however, no provision is being made for treatment of the fines, but is being postponed until such time as the trend of fine ore concentration is clearly defined.

Several wash ore plants are being anticipated for the future and may or may not be ready for next season, depending on ore requirements.

Magnetic Separation and Flotation. — A single unit has been erected on the east end of the range for the concentration of the magnetic taconites. This work was hampered by the strike, but it will be continued as it showed promise of producing a satisfactory grade concentrate.

The one flotation pilot plant, which has operated for several years, continued during the past season. Data is being accumulated against the day when the economics of this means of concentration will warrant consideration. The greatest emphasis at this time seems to be placed on pelletizing the fine concentrates from flotation or magnetic concentration to produce a uniform size of finished balls which will have the physical properties necessary for transportation. Outside of this effort, endeavors are being made by several companies to make a comprehensive study of the various flotation procedures developed to ascertain which combination of reagents will prove most satisfactory in recovery of the iron units. Outside of magnetic roasting, flotation appears to offer the most promise. This, however, could change if natural gas or some other cheap fuel could be introduced into the district, in which case magnetic roasting and separation would have to be reconsidered.

Beneficiation for the Mesabi Range ores at the present time is in a general state of flux. As said heretofore, the combined efforts of all the mining companies appear to throw a cloak of confusion over the general trend of research. Fortunately, in spite of this, progress is being made. The rapidity or lack of it can only be measured in terms of practical application, for after all, the primary purpose still continues to be to make an honest dollar, thereby resulting in a profit which in turn makes it possible to extend the research programs.

COAL

Foreword—by E. R. Price

The coal industry was beset with work stoppages and strikes throughout the year, and there was some loss in markets to oil and gas. These conditions, along with the mild decline in industrial activity, the steel strike, and the reduction in exports, contributed to an unfavorable year for the industry.

All coal mines are working three days a week at the time of writing, and in estimating production for the year, it will be assumed that the mines will continue to work on that basis through December.

Total production of bituminous coal in 1949 is estimated at 420 million tons, which is 179,518,229 tons under the production in 1948. Anthracite production is expected to reach 39,400,000 tons as compared with 57,139,948 tons in 1948, a loss of 17,739,948 tons.

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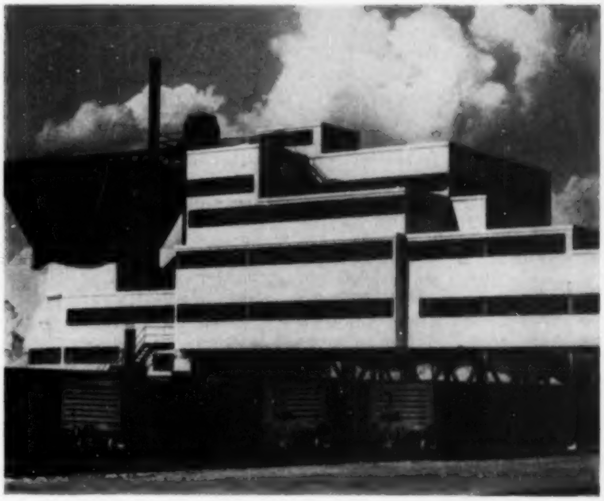
Coal stocks, as of January 1, 1949, were 69,373,000 tons but at the end of the year will have dropped to approximately 22 million tons.

Regardless of the difficulties during the current year, the industry has made substantial



PROGRESS in 1949 in the coal industry has been along technological lines rather than in production records. Production in bituminous is off about 40%, and 30% in anthracite over 1948. A loss in markets has been felt. Continuous mining, gasification, synthesis liquid fuels, and utilization development show great progress.

technological advances in all phases of production, preparation, and utilization. The progressive improvement in its safety record is also outstanding.

The continuous mining and loading machines introduced in 1948 are now figuring prominently in the coal industry's plans for the future. Several different types of machines are now in operation, others are undergoing tests and one or two are in the course of development. Several manufacturers are getting ready to place on the market equipment to provide efficient transportation of coal from the continuous mining machines.

Research in coal utilization was carried on during the year by organizations within the industry, also by individual coal companies and by government agencies. Noteworthy are the experiments in underground gasification of coal without mining it; the process of converting coal into synthetic oil, gas, and bulk by-product chemicals; the development of household heaters; and the coal-burning gas turbine locomotive.

New developments in production and utilization, as well as the progress in the field of preparation, will be described in more detail elsewhere in this review by the chairmen of the various technical committees of the Coal Division.

Technological advances in different phases of production, preparation, and fuel utilization, which have been brought about by engineering skill and through large research programs, have placed the industry in position to expand with the growth in demand for mineral fuels.

A predicted sharp upswing in the requirements for fuel energy, not only in the United States but throughout the world, portends a bright long-run outlook for coal. But it will be necessary for the industry to solve its labor relations problem before it can fully participate in the increased demand for mineral fuels.

Achievements in the mechanization of mining operations and in preparation, all of which are designed to lower costs and improve the product, will not, of themselves, enable the industry to hold or to increase its percentage of the country's requirements of mineral fuels. Consumers must be able to rely on a constant and dependable source of supply of coal at a cost competitive with other mineral fuels. That cannot be accomplished unless labor and management can avoid work stoppages which have plagued the industry this year.

In 1949, the nation's coal supply was curtailed

by the unilateral and dictatorial action of the United Mine Workers of America in designating a "memorial period" in March and a "stabilizing period of inaction" in June. When no agreement was reached on the terms of a new contract to replace the National Bituminous Coal Wage Agreement, which expired June 30, 1949, the United Mine Workers put into effect a "three-day work week" in certain areas of the country, from July 5 to September 19. At that time, a strike or "no-work week" was called by the Union, which carried through to November 10, when the mine workers were again instructed by the Union to resume production under the terms and conditions of the contract that expired July 1, and to continue at work until December 1.

On December 1, the Union again established a "three-day work week" and how long that unsound and uneconomic schedule of operation will continue is a matter of conjecture. How to avoid these strikes and work stoppages remains industry's most perplexing problem at the close of the year. It is not too much to expect that leaders in both labor and management will find the way. Labor must not be permitted to place restrictions and limitations on the use of new plant facilities and equipment if coal is to be preserved as the dominant source of the fuel and energy requirements of the nation, and as the source of the future supply of raw materials for the chemical industry.

The industry is aware of the importance of coal to our economic life and prosperity. It also realizes the social necessity for the conservation and prudent development of this irreplaceable natural resource, and is directing its efforts to the accomplishment of these ends as well as toward a reduction in accidents and in greater efficiency and economy in production.

Preparation

by R. E. Zimmerman, W. J. Parton, Orville Lyons, and Wm. McMorris

Continuing the upsurge in preparation plant construction started so actively in 1948 following the easing of steel and machinery supplies, 1949 saw feverish construction of both large and small plants, as coal producers faced highly competitive markets.

In addition to competition in the selling of coal, there has been the rapid and almost total adoption of various forms of mechanized mining which in turn has frequently changed mining methods to that of "total seam" mining, with the consequent increase in impurities of the run-of-mine. Some mine operators find as much as 25 to 35% refuse material must be removed from their mine output to make their product competitive.

Two trends in preparation plant capacities have been noted. One is in the direction of large central washeries handling feed of 500 to 2000 tons per hour, and the other is toward small plants having capacities of 150 to 50 tons per hour. Small operators are keenly interested in the installation of low-priced unit washeries for capacities under 150 tons per hour, and 1949 saw a large number of new installations in this capacity range. Several mobile-type plants are on the market that are portable or semiportable. Increasing attention may be paid in the future to the design and construction of these plants.

High labor costs and decreasing need for lump coal are eliminating the need for manual picking of refuse from larger coal sizes. This is being accomplished by increasing the top size cleaned mechanically to as high as 8 or even 10 in. and crushing the oversize. Single and double roll crushers and Bradford breakers are used.

To meet the increased demand for stoker sizes many plants are installing crushing and elaborate screening equipment. However, elimination of large sizes plus increased degradation in the run-of-mine as a result of mechanical mining has brought about the attendant increase in coal fines and with it more and more equipment for cleaning, drying, and handling these fines.

Although in 1949 as in 1948 the Baum-type jig is the most common type of washer, increased attention and more installations are being made of the dense-media type of cleaning processes. The methods employed usually consist of using finely ground magnetite or finely sized sand kept in suspension in water. Accurately controlled specific gravities are maintained, and conditions approaching true float-and-sink separations are achieved.

Sand flotation is the oldest of the dense-medium processes in the United States. Separation of coal from its refuse is made in a cone-shaped vessel. The coal is floated off at the top and the refuse drops out of the bottom of the cone through air-operated slide gates or into an elevator boat. A recent innovation on the refuse discharge is the use of air-actuated butterfly gates. Another change in the apparatus being experimented with in Great Britain and being installed in at least one new plant in this country is a middling drawoff where it is possible to separate middle gravity material for retreatment.

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Magnetite is being employed in either cone-shaped or drum-type vessels, in an Akins-type classifier. There has been no installation in this country of the dense-media types similar to the Barvoys, Ridley-Scholes, Tromp or Dutch State Mines vessels common in Europe. Several installations are now using calcium chloride dissolved in water to maintain, together with some agitation, the desired specific gravities necessary to

An off-the-highway 35-ton Diesel-powered truck used to transport coal from the mine to the preparation plant at the Old Ben Coal Co., West Frankfort, Ill.

separate coal from its impurities. This method is especially adaptable for small unit washers. Experimental work is exploring the possibilities of the Dutch State Mines cyclone as a dense-media cleaner, especially for the finer sizes of coal. The results of its practical application in this country are being awaited with interest. Dense-media processes are generally limited to sizes above ⅛ in. and perhaps preferably above ¼ in. This requires prescreening ahead of the separating vessel.

Classifier-type washers are holding their own. Numerous plants are in use and most of the installations in the Pennsylvania anthracite field are of this type.

Possibly one of the lessons to be learned in coal preparation is that the coal industry can use various kinds of coal cleaning processes equally well under certain conditions and that it is a matter of choosing the type best suited for one's particular needs.

For wet-cleaning of fine coal various processes are being used; namely, concentrating tables, launders, hydrotators, and perhaps in the future, the cyclone. Sometimes combinations of these processes are installed with concentrating tables being used to clean up middlings. Spiral-type separators are used at two anthracite installations.

Although hydraulic classification of table feeds has been standard practice for many years in the recovery of valuable minerals from their ores, only in the past year has a classifier been developed for handling the large loads and volumes necessary in wet coal preparation. As much as 100 tons per hr of ¼ by 0 bituminous coal is reported being classified at a large preparation plant by each of a battery of 8-cell Concenco Super Sorters. This particular plant has four 8-cell units in operation. Products from the first two spigots contain refuse clean enough to be disposed of direct.

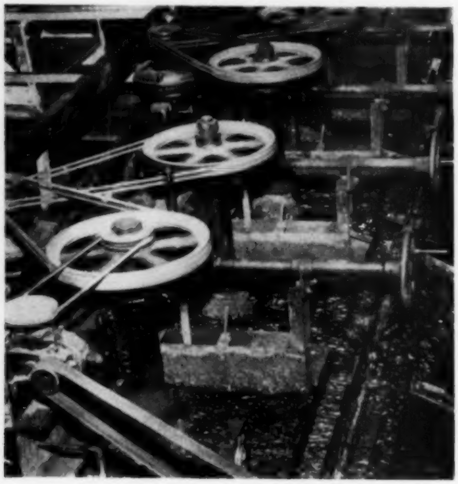
Air tables have been accepted to clean ⅜ by 0 size coal at a number of plants. The possibility of predrying ahead of air tables to give more uniform feed conditions is being investigated. The use of air tables on sizes of coal in the range of ½ in. to perhaps 14 mesh needs study, especially in coal areas where only a moderate reduction in slack ash is a market requirement.

The cleaning of extreme fines in the form of slurry or silt is becoming more important. Among the reasons are: increased value of extreme fines, the economic necessity of recovering this material, the greater percentage being produced as a result of mechanical mining, and the restrictive laws in some states prohibiting stream pollution.

Two methods of flotation are being employed, the froth flotation process and the kerosene agglomeration process. Numerous plants are operated and are being installed in the anthracite region using froth flotation for cleaning silt from breakers and old silt banks. One froth flotation plant has been in operation in western Pennsylvania for a number of years, one was installed in 1949 in Illinois, and a new plant is being erected for operation in 1950 at a colliery producing metallurgical coal in southwestern Pennsylvania.

The process called kerosene, oil, or agglomeration flotation has been demonstrated successfully in Alabama and holds considerable promise. Although using larger quantities of reagents or oils it has the advantage of producing a drier concentrate. In connection with this same process a dewatering screw has been installed on the machine to aid in further dewatering of the product.

With the increase in the wet cleaning of fines taking place throughout the country the necessity for filtering and drying of these fines has become a problem of major importance. The merits of the various types of centrifugal and thermal dryers on the market are being compared by preparation men.



Flotation cells used to recover coal fines at the Lehigh Navigation Coal Co.

Although solid-bowl-type centrifuges are being placed in operation to clarify slurry in some places, the standard methods are still the use of settling ponds, thickeners and at an increasing number of plants, a combination of thickener and vacuum filters. Vibrating screens may be used for this purpose, and some success has been reported with the mechanically vibrated and the electrically vibrated types. Cyclone thickeners are being installed in increasing numbers and a varied report has been given of their success. In addition to the Dutch State Mines cyclone or various modifications of it, another type has been installed at some operations. It is called a Vortrap and has been used for years in the paper industry for clarifying pulp water.

Most of the fine clean coal we produce is cleaned by wet washing methods. This practice, coupled with the fact that it has become more necessary to produce low-moisture fine coal products, has increased the use of thermal dryers to dry fine coal at the preparation plant and has materially increased the interest of the coal industry in the matter of thermal drying.

At present only four types of dryers are being installed in new preparation plants. These dryers include the screen-type, a recently developed vertical-cascade-type, the flash-type, and the multi-louvre-type. A number of new types are being designed and readied for use but only one, a continuous belt, up-and-down draft design, has been offered to the coal industry and no units of this new dryer have been installed.

The screen-type dryer is being used to dry 2-in. by 1/8-in. coal, 1¼-in. by 28-mesh coal, ¾-in. by 28-mesh coal, and ½-in. by 28-mesh coal. The vertical-cascade-type dryer is being used to dry 1¼-in. by 10-mesh coal and ½-in. by 28-mesh coal. The flash-type of dryer is being used to dry ¼-in. by zero coal, 3/16-in. by zero coal, and 1/8-in. by zero coal. The multi-louvre-type of dryer is being used to dry ¼-in. by zero coal and 3/16-in. by zero coal. These sizes do not necessarily represent all of the sizes being dried, but merely indicate the range of sizes being treated.

Several operating companies have been faced with dust collection problems after installing either flash or multi-louvre types when attempting to dry coal containing a high percentage of minus 100-or 200-mesh material. In attempting to collect this dust, installations have been made using special types of cyclone dust collectors, bag-type collectors, and water spray systems. At one plant using a water spray system the fine wet dust is concentrated by froth flotation and dewatered by a vibrating screen. The dust collection problem is being solved, and these types of dryers may become even more acceptable to the coal industry.

Another problem getting more attention from preparation plant operators is that of refuse disposal and the prevention of refuse pile fires. Scientific and engineering studies on the cause and cure of refuse fires are being made by the Mellon Institute and The Pennsylvania State College.

Nonfuel Utilization

by H. B. Charmbury

Although there have been no developments in the nonfuel utilization of coal during the past year which will result in large markets for the coal industry, the interest in this phase of utilization has been gratifying. The year's developments may be divided into two groups, industrial and fundamental. The industrial developments include completion of the Buena Vista, Calif. plant of the American Lignite Co. for the extraction of montan wax from lignite, the completion of the coal-to-oil demonstration plant of the Bureau of Mines for the production of liquid fuels and chemicals from coal by hydrogenation, the utilization of fly-ash in various industries, and the utilization of anthracite and bituminous coals as soil conditioners and fertilizers. The fundamental developments include investigations on the extraction, oxidation, and hydrogenation of coal.

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The new $250,000 plant for the extraction of montan wax from lignite is being operated by the western division of the De Angelis Coal Co. of Carbondale, Pennsylvania and commercial shipments from the plant were reported as early as February, 1949. It is hoped that as a result of the plant, the United States may become independent of foreign sources for this product. The wax can be substituted for the imported Carnauba wax when color is not disadvantageous. Plant byproducts include sap brown, a dye used in the paper industry; van Dyke brown, a paint pigment; and mud briquets, used in the fertilizer industry.

The 200 to 300-barrel-per-day demonstration plant of the United States Bureau of Mines at Louisiana, Mo., was placed in operation for the first time during the past year. This is the first commercial step by this country to insure a satisfactory supply of oil products should our domestic and imported crude oil supplies become depleted.

Although fly-ash results from the combustion of pulverized coal, the production of more than two million tons of this material annually constitutes one of the more important potential nonfuel uses of coal and its products. Developments have continued in an effort to increase the utilization of this material in the cement, brick, paint, insulation, and road-building industries as well as in soil conditioning and filtering processes.

Since reports on the direct application of carbon black to the soil for plant protection in cold weather have appeared in the literature, the possible utilization of anthracite for this purpose has been investigated. It has been reported that the addition of carbon black will lower the freezing temperature of the soil.

Agricultural field tests on the possible utilization of ammonium humates, prepared from bituminous coals, as a possible source of nitrogen for plant growth have been continued at The Pennsylvania State College. The humates have been tested in the growth of corn, wheat, barley, and grass.

Investigations on the extraction of waxes from lignites have been conducted at the Central Experiment Station of the Bureau of Mines. Arkansas and California lignites produced the highest yields and benzene was found to be the most desirable solvent.

Water-soluble polycarboxylic acids from the oxidation of bituminous are being produced in the coal research laboratory of the Carnegie Institute of Technology. During the past year studies were continued on the chemical nature of the more complex acids obtained from the process. The results have contributed to a more thorough understanding of the chemical nature of coal.

The chemical nature of humic acids prepared from the oxidation of bituminous coal has been studied in the fuel technology laboratories of The Pennsylvania State College. Investigations on the solvent extraction, ozonolysis, and thermal decomposition of the acids have contributed to the existing knowledge of their chemical constitution.

Laboratory investigations on the hydrogenation of coal have been continued in the coal research laboratory of the Carnegie Institute of Technology. Tests were conducted to determine the effect of time and temperature on the chemical nature of the primary products and to determine the importance of the coal sulphur during hydrogenation. The results have contributed to a more thorough understanding of the process for the conversion of coal into oil.

Investigations on the chemical mechanism of the coal hydrogenation process have been continued in the fuel technology laboratories at The Pennsylvania State College. Pure compounds have been hydrogenated under conditions similar of coal and the results during the past year have contributed to information on the removal of nitrogen during the process.

Some of the more important investigations on coal hydrogenation at the research and development laboratories of the Bureau of Mines dealt with the evaluation of catalysts and the utilization of a fluidized bed in carrying out the process. Iron catalysts such as ferrous sulphate, pyrite, and red mud were found to be quite satisfactory in promoting coal liquefaction although not as effective as tin or zinc plus ammonium chloride. Preliminary experiments on hydrogenating dry coal in a fluidized bed at relatively low pressures were rather encouraging and the process would eliminate some of the undesirable features of the Berzius-I.G. process.

Combustion

by T. S. Spicer

It would be a pleasant task to paint a glowing picture that all is well with the coal industry's market. Such a truthful report is not possible. Fortunately the ever increasing population of America will need more and more energy and thus the coal tonnage consumed may not shrink even though there be a percentage-wise shift in the type of fuel consumed.

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The direct use of coal as a primary fuel represents the majority market. Heat from the combustion of coal warms our homes and buildings, generates process steam for industry, supplies steam for transportation and the generation of electricity and for many industrial processes. In the year 1949 as in the preceding years the coal industry has fought stubbornly to defend itself by seeking more efficient utilization for its customers through research and development. In plain words this means better service at a lower cost. While this constructive work was under way there have been simultaneous factors which have affected the over-all progress. Coal has always been recognized as a dependable, cheap source of energy, but due to the unfortunate "on and off" effects of strikes this fact is not as true now as it was in the past. Coal has not been as dependable as it could be and moreover the price is such that competitive liquid and gaseous fuels are steadily gaining. Increased freight rates have further added to the final cost of solid-fuel heat units to the consumer.

The price of industrial fuel oil along the seaboard is still a very serious threat to the coal industry. The possibility of oil imports from the devalued British Pound area may further contribute to low-cost oil. Gas pipe lines are being promoted in all sections of the country and many are being approved by the Federal Power Commission. This allows the dumping of quantities of gas in areas which they cover, particularly for

the first two or three years until increased markets are established in the small user field. The sale of domestic stokers has further declined during 1949 and many coal users are converting their furnaces to oil or gas.

A survey by the *Philadelphia Evening Bulletin*, shows that homes in the Philadelphia area were heated by the following fuels shown in the table. These data are significant but do not show the actual quantities used.

Fuels Heating Philadelphia Homes in Percent

	Suburban		City	
	1949	1949	1948	1947
Coal	49.3	52.9	57.0	65.8
Oil	42.7	33.9	32.1	21.0
Gas	5.5	8.6	5.6	5.3
Coke	2.2	4.6	5.4	7.8

Our exports of coal have declined and, besides, shipments of British anthracite to Canada have increased sharply between 1948 and 1949. Percentage wise, the latter are still rather small but the trend is nevertheless there.

The United States consumes more electricity than all of the rest of the world combined and a further increase is expected. As a result utility power plants are under construction over many parts of the country. The utilities are not only the number one users of coal but they should require even greater quantities. Railroads formerly held that position up until last year and they will probably use less and less coal in the years to come with replacement of the steam engine by the Diesel.

The coal industry is continuing to fight back through its research and development. The anthracite industry, with their research laboratory at Wilkes-Barre, have continued to improve the older types of combustion equipment and develop new ones. A new stoker called the Anthraflow (a cross-feed type of stoker) has joined the Anthratube to make a bid for the domestic market. Reports indicates that these are being well received by the home owner. Studies are under way for vacuum or pneumatic removal of ashes in domestic and small heating plants to add to the automatic nature of the stoker. Renewed anti-smoke activity is in the anthracite industry's favor but this is only a negative approach toward improving and expanding the over-all market.

A number of cement plants in eastern Pennsylvania adjacent to the Pennsylvania anthracite production area are satisfactorily burning about one fourth and in some cases up to one half of anthracite fines (#4 Buckwheat and smaller), with bituminous coal in pulverizing firing of rotary kilns and thereby effecting substantial savings in delivered fuel costs.

There are other favorable signs for the industry. The opening of the new Bureau of Mines anthracite station at Schuylkill Haven should be announced in 1950. Investigations related to mining, utilization and preparation will be conducted there. A new Anthracite Standards Law of Pennsylvania went into effect on Sept. 1, 1949. It applies to all sizes—broken to rice inclusive. All anthracite steam sizes must be attested by the producer as either "standard anthracite" or "substandard anthracite" whether shipped to a point within or without Pennsylvania. Every sale to a consumer in Pennsylvania must be accompanied by a statement that the anthracite is either one or the other quality. This protection of the customer by the assurance of receiving a good anthracite will help the situation. New utilities stations adjacent to the anthracite field are either being installed or being contemplated. This steady expansion of anthracite-fired steam electric stations is a rather important trend.

The actual consumption of coal is not available but the production as of Nov. 5 for the bituminous mines was approximately 352,000,000 tons as compared to 505,000,000 tons for the same period in 1948. This means about a 30% decrease.

Smokeless stoves are beginning to appear on the market. They are reported to cost a little more than the conventional stoves and buyer resistance may be encountered which can be attributed to the fact that the customer may feel he should not pay his way for clearing up the atmosphere. The Pennsylvania stoker developed at Penn State is still in the production-design stage at the Timken silent automatic plant. There is still a real need for a low cost stoker which will burn the strongly-coking and fine-size consist coals.

The single retort stoker which in the past has serviced most of the small plants is under the most severe competitive pressure of all industrial coal-burning machines. There has been a drastic reduction in the number installed in 1949, with some of this business going to spreaders and others to oil or gas. The increased cost of boiler-room labor in some cases has reversed the economy of coal. Research work is being conducted at the coal combustion laboratory at Penn State to help make this machine more acceptable. Laboratory facilities for conducting this work have been expanded during the past year. It is probably the only laboratory of its kind in the United States. The use of suspended arches or ignition baffles at the coal combustion laboratory indicates that the performance may be improved by the use of these devices. Fortunately they may be installed in either existing or new installations.

Few multiple retort stokers are being installed yet this machine is still an important user of coal due to the many existing installations. The spreader stoker is gaining in popularity, with the use of a traveling grate plus improved fly-ash collectors making it a machine more and more desirable.

R. K. Allen of the Babcock and Wilcox Co., in a recent paper at the Joint Fuels Conference at French Lick Springs, discloses the following: "Approximately 22% of all new coal-fired boiler capacity installed during 1946 was spreader-stoker fired. In 1946, 66% of coal-fired capacity was pulverized coal. Pulverized coal not only dominates the larger field but it also competes with the spreader machine in the intermediate field. Fifty years ago practically all new power installations were coal fired whereas the statistics for 1946 show that approximately 43% of the capacity installed that year was initially oil or

gas fired." Admittedly these figures are not for 1949 but they do show the trend. Operators of big steam generators are no longer dependent on any one fuel but can burn oil, gas, or powdered coal separately or in combination. Both labor and industry should take heed that no longer can this customer be forced to burn this or that type of fuel but instead he can play the market and use the cheapest Btu available. Spreader equipped boilers likewise may be fired by auxiliary burners.

The cyclone combustion furnace appears to have great promise. Although developed primarily for coal it can be used to burn gas and oil.

The Bituminous Coal Research organization is conducting a strenuous diversified program and their work is contributing to better utilization. The coal industry is banking heavily on the coal-fired gas turbine locomotive which it is hoped will be the savior of the railroad market. The Bureau of Mines and numerous other research organizations are conducting fundamental and applied studies of coal uses.

Coal Carbonization

by Frank H. Reed

The inroads which are being made upon our reserves of premium quality coking coals are resulting in increased interest in the metallurgical coke problem. Evidence of this was apparent in the survey program started in 1948 by the Bureau of Mines, assisted by the Coal Resources Committee of the National Bituminous Coal Advisory Council—a survey begun in the Appalachian area but planned to extend to every coal producing state. A reliable and comprehensive estimate of the nation's reserves of minable coking coal will be the result of this effort.[1]

In the meantime, various agencies are working on methods for making acceptable metallurgical coke from coal blends containing appreciable proportions of more weakly coking coals. The trend is likewise revealed in the fact that some coke-oven operators are planning and constructing mixing bins to facilitate control of blending operations.

P. S. Savage has described[2] the use of weathered Pocahontas outcrop coal and the admixture of anthrafines in coking blends, stating that up to 4 to 5% Pocahontas could be replaced by anthracite without hurting the coke. The use of coals of higher volatile matter content than the usual low-volatile Pocahontas is receiving consideration, as indicated by the patent issued to George E. Brandon and assigned to Allied Chemical and Dye Corp. This describes the manufacture of blast-furnace coke by high temperature carbonization of blends comprising 80% bituminous coal of 27 to 38% V.M., 15% bituminous coal of 14 to 23% V.M., and 5% blast-furnace flue dust containing 70 to 90% iron. The claim is made that the resulting coke is hard, strong, and free from excessive fines.

A third possibility for conserving low-volatile coking coals is the production of chars for blending with high-volatile coals in producing metallurgical coke. These chars are produced by partially devolatilizing high-volatile coals. The Illinois State Geological Survey is now engaged in a program of preparing such chars of volatile content in the range of Pocahontas coals and testing the coking properties of the chars when blended with Illinois high-volatile coals.

During the summer of 1949, a Japanese plant started operation of a 700-ton blast furnace using coke made from a 75-25 mixture of Japanese high-volatile coking coal and low-temperature coke, or char, made from a Japanese high-volatile, noncoking coal. Good coke practice in the blast furnace is reported. This plant has, therefore, become independent of imported coals.

Perch and Russell[3] have described a procedure by which the "criteria used for the standard classification of coals can be arranged so that coals of all ranks lie on a single curved line," making it possible to "compare the coking behavior of one coal with another." Although "exact correlation of coal rank with coking behavior has not been achieved," these authors believe that the use of their charts together with Gieseler plastometer data can be "an important guide in the selection of coals."

The Bureau of Mines described a new experimental oven which has been constructed at the Tuscaloosa, Ala., station.[4] This oven features 17 in. width, electrically heated silica brick walls one of which is movable and designed to measure coking pressures up to 10 psi, and zoned heat input arrangements so that temperatures of the walls can be controlled at any desired value. This oven is designed to be, in all essential respects, a small section of a modern industrial by-product oven.

In the field of low-temperature carbonization primarily for the manufacture of domestic fuel, a noteworthy step has been made in the construction and initial operation of the new plant of the Disco Co. near Pittsburgh, Pa. The essential features of this new plant, which converts bituminous coal fines to coke balls, were described by R. S. McBride.[5]

Gregory and McCulloch[6] described the construction and operation of the new Stansfield retort in which up to 144 lb per hr of subbituminous coal may be carbonized, using flue temperatures up to 500C and producing a yield of char 50 to 56% by weight of the coal charged. Dry, ash-free volatile matter of the char produced varied with carbonizing conditions from approximately 10 to 25%.

[1] Heating & Ventilating, Aug. 1948, p. 69.
[2] P. S. Savage, Blast Furnace & Steel Plant, 37, 323 ff. (1949).
[3] Mining Engineering, 1, No. 6, 205-14 (1949).
[4] Fieldner and Gottlieb, USBM Information Circular 7518, p. 67, (Aug. '49).
[5] Chemical Engineering, 56, No. 6, 112-114 (1949).
[6] Ind. Eng. Chem., 41, 1003-11, 1949.

Thus, primary attention in the field of coal carbonization in 1949 was directed toward a sur-

vey of our high-quality coking coals and toward finding means of utilizing coals hitherto considered as marginal or poorer coking coals. Work is in progress also to make available suitable substitutes for Pocahontas, the reserves of which are becoming depleted.

Coal Gasification

by Milton H. Fies

A survey of the work being carried out in the field of coal gasification during 1949 reveals many noteworthy developments. Much of the work is in an experimental stage, but results already obtained indicate that the near future may hold great possibilities in connection with coal utilization. One important commercial development in gasification has been the modification of the Du Pont water-gas plant at Belle, W. Va., to permit the gasification of coke by a continuous process using oxygen instead of the cyclic air blast. It is reported that this will make the production of synthesis gas from coal as a basic raw material more attractive since it will result in lower coke requirements. This example of the use of oxygen in a commercial gasification process is of especial interest in view of experimental work on processes for the gasification of coal involving the use of oxygen.

The author is a consulting engineer, Birmingham, Ala., and a member of AIME.

As part of the synthetic liquid fuels program, the Bureau of Mines, through its Synthesis Gas Production Branch at Morgantown, W. Va., in cooperation with West Virginia University, is continuing its extensive program devoted to the production of synthesis gas by the gasification of pulverized coal with the aid of oxygen and steam. Pilot plant facilities include two gasifiers and a gas purification pilot plant. Coals, which have been successfully gasified, range from lignite to anthracite and have included strongly coking coals. Pilot plant operations have made use of highly superheated 3600F steam with a consequent reduction in the amount of oxygen required to supply the necessary endothermic reaction heat. Preparations are being made to study the gasification of pulverized coal at pressures up to 500 psig. This pilot plant will have a capacity of about 500 pounds of coal per hr. Among other advantages, pressure gasification is expected to result in a reduction of compression costs in connection with those processes utilizing synthesis gas under pressure.

Experiments in the underground gasification of coal, carried out by the Bureau in cooperation with the Alabama Power Co., have attracted considerable interest. Construction of this project at Gorgas, Ala., was completed and operation was begun during March, 1949. All operations to date have been conducted on the first 300 ft length of the passageway, which altogether is some 1550 ft long. From the section which has been used, some 3000 tons of coal have been consumed. Thus far, the energy of the coal has been largely brought to the surface in the form of sensible heat in the product gases, which can be used for generating steam at the outlets from the system. However, in the last 2½ months of the experiment a producer gas has been made along the burning faces of the coal which ignites at the borehole outlets. Effort is being made to block off and divert the uncombined air by the use of fluidized sand and thus make the gas available at the surface.

At Louisiana, Mo., the Bureau's synthetic liquid fuels demonstration plant has put into operation a gasifier intended to supply the requirements of synthesis gas for the Fischer-Tropsch process. This gasifier, operating at atmospheric pressure, utilizes pulverized coal, oxygen, and steam, but differs from the experimental plant at Morgantown with respect to the amount of superheat used in the steam and certain design features. For this gasifier, provision is made to superheat the steam to temperatures ranging from 1800 to 2500F. The oxygen used is produced by a Linde-Frankl plant which was brought from Germany and set up by the Bureau engineers. The gasifier can utilize widely varying coals, although tests to date have employed Wyoming coal.

In cooperation with the Southern Natural Gas Co., the Bureau at the Central Experiment Station in Pittsburgh studied the production of methane as a possible replacement for natural gas. Synthesis gas was produced by the Lurgi process and conversion of the synthesis gas to methane was effected catalytically. The Lurgi process, which was originally developed in Germany, operates at about 300 psig and employs a fixed bed of char. Char was prepared from coal by devolatilization of coal in gas-fired equipment, developed by the Bureau.

The Institute of Gas Technology at Chicago, Ill., has carried out experimentation on pulverized coal gasification on a small scale as part of the gas production research program of the American Gas Association. Plans are being made for a study of pressure gasification, but unlike the program planned by the Bureau of Mines at Morgantown, pressure will be limited to 90 psig.

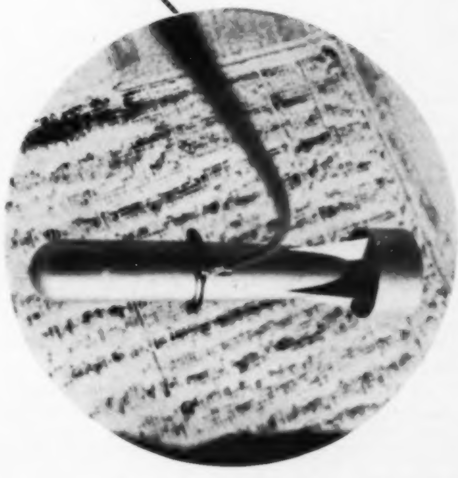
The widespread interest in coal gasification is reflected by the activities of various oil companies who are understood to be carrying out experimental studies. An example of this work is the program of the Standard Oil Co. in collaboration with the Pittsburgh Consolidation Coal Co. at Library, Pa. No experimental results or process descriptions have been published in connection with the work being carried out by the various oil companies.

It is believed that the development work now being carried out in the field of coal gasification has important implications to the coal industry. Cheap natural gas has become a competitor with coal as a source of synthesis gas; several plants have already located in Texas for this reason. Development of a cheap process for the production of synthesis gas from coal could reverse this trend, not only preventing a loss of market for coal, but increasing the demand.

Geophysics — Progress and Prospects

by Sherwin F. Kelly

One of the most succinct and illuminating perspectives of the field of geophysical exploration to appear in recent years is an article by E. A. Eckhardt, in the magazine *Geophysics* for October 1949. Although his review covers the year 1948, many of the data presented are *apropos* to a review of 1949, and form a pertinent background for a consideration of current progress. He presents charts of the world-wide distribution of gravimeter and seismograph activity in oil exploration, which show that surveys in the United States accounted for practically 68% of all gravity work and 80% of all seismic activity. Canada ranked second, with a proportion of roughly 6% in each case; South America accounted for about the same percentage of seismic work, and double that amount for gravity surveys. Within the United States, Texas and Louisiana were the scenes of the greatest activity, both claiming about 60% of all surveys by each method.



Resistivity survey being made on brown iron ores in Alabama.

Magnetometer operations ranked a poor third in terms of crew-months or dollars spent; but Eckhardt estimated that the airborne magnetometer rated an unquestioned first in terms of area mapped, more territory having been covered by these instruments than by seismic surveys all over the world, at a cost of only about 2% of those seismic operations.

Data on mining geophysics are more difficult to assemble, but the charts presented show that approximately 50% of such work was carried out in Canada, 20% in the United States, and about 15% in Australia. Division of this work, as between industry and government, should be given careful attention. India's 3½% was almost wholly government operated; South Africa's 7% was wholly industrial. Between these extremes lie Canada, Australia, and the United States. Of the United States' share, over half was government conducted, leaving for industry's account only 9% of the world total. In Australia, the government's work accounted for a little less than half, and industry's share was again about 9% of the world-wide activity. The value of mineral production exclusive of fuels for the year 1946, the latest statistics which are available, show that for the United States it was in the neighborhood of **3 billion**, and for Australia about **3 million**. In Canada, the mining industry supported 95% of geophysical exploration, for a world share of about 46%. Free enterprise seems to be healthier up north.

As between methods, magnetic ranked first in mining exploration with nearly 49% of the world total and electrical methods second with 31%. Gravity techniques are coming into use in the mining field and accounted for 12%, seismic work amounted to 2%, and geochemical to 1½% of the total. Radioactive methods were not overlooked and rated nearly 5% of the total.

In concluding his article, Eckhardt compares geophysical expenditures with mineral production. In the United States, the cost of geophysical work in 1948 was about 0.025% of the value of mineral production, and in Canada about 0.25%. The comparable figure for petroleum geophysical work was a little over 1%. In terms of cash money, the petroleum industry spent $125 million and the mining industry $2 million on geophysics.

According to data now available, geophysical activity in United States oil fields decreased somewhat during 1949, and a notable drop took place in South America. The falling off was more pronounced in seismic than in gravitational work. In Canada, on the other hand, the upsurge was striking. In October 1949, an area of 100 million acres of Canada's prairie provinces were being worked over by 104 geophysical crews. This figure was only a little less than a quarter of the number of crews reportedly working in the United States at that time. The magnitude of this change can be appreciated by comparing the relative percentage figures for 1948, cited above. A majority of the work in Canada's oil fields is being carried out by American geophysical operators, although some Canadian companies are in the field. Of the crews operating, 73 were seismic, 29 were gravity, and 2 were magnetometer.

Considerable interest is being shown in the application of geophysics to the discovery of limestone reefs, due to recent such discoveries in Venezuela, west Texas, Canada, and the Middle East. In the latter area, geophysical activities continue unchanged, but in the East Indies an increase is reported. In India, the only privately conducted geophysical work is carried on by the Burmah Oil Co. From 1942 to 1948, it conducted a torsion balance study in Upper Assam in an effort to trace the trends of two alluvial-concealed thrust faults. These results, analyzed in 1949, failed to give the required data, and a gravimeter survey is now proposed together with a telluric current study.

One of the most important developments in the last few years has been that of seismic equipment for underwater surveys, and the past year has been distinguished by the magnitude of such operations in the coastal waters of California and

the Gulf of Mexico. The same large-scale operations have characterized the field of airborne magnetometry. A marine version of this instrument, to be towed on a small barge, has been developed by Frost. A new airborne magnetometer has been produced by Gulf Research with an improved speed of response to signal. This characteristic is important for possible applications in the mining field.

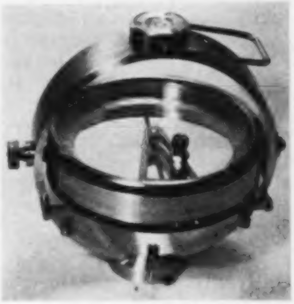
The interpretation of magnetic and gravimetric observations was put on a sounder theoretical and practical basis by several papers which appeared in 1949 by Skeels and Watson, by Henderson and Zeitz, and by Peters. Their various labors demonstrate the nonindependence of the various derivatives of gravitational and magnetic potential, the possibility of calculating the continuations upward and downward of a given field, and of estimating depths to igneous basement rocks. This adds up to an important conclusion—that it is unnecessary to fly more than one level in airborne magnetometry because other levels can then be calculated.

In airborne or surface work over water, the accurate determination of observation position is difficult, but essential. Shoran and radar were carried over from the war but new techniques have been perfected in the last year or so by the Hastings Instrument Co. and by Seismograph Service Corp. The latter's system, called Lorac, depends on measuring the phase differences of radio waves received from two stationary, continuous-wave transmitters. The Raydist system of Hastings is reportedly similar.

In the gravity meter field, remote-controlled, underwater gravimeters have been developed by La Coste-Romberg, R. H. Ray, and North American Geophysical Co. These meters can be lowered to the sea bottom, and then controlled and read by boat-mounted electrical equipment.

A striking deviation from traditional shooting practice in seismic prospecting has been perfected by T. C. Poulter of Stanford Research Institute. The development is an outgrowth of his research on the Ross shelf ice during the Byrd antarctic expedition of 1933-35. In the Poulter method, the explosive charges are placed six feet above ground, with the result that the transmission of energy is better, and that the early parts of the records are cleared up to such an extent as to permit the recording of very shallow reflections. The latter point will be of importance in mining applications. This new system was applied by Dr. Poulter to glacier studies in Alaska, and, for the first time, accurate determinations of ice thickness, even in excess of 1000 ft, were made. Good reflections were obtained, sometimes with an explosive charge of one ounce, during the studies on Taku Glacier.

The past year also saw the disclosure by William Barrett of a new electrical prospecting technique, the Radoil method, by which, it is claimed, the presence of oil, *per se*, can be detected. He furthermore reports that the principles of the technique are being applied in a research program to the search for metallic deposits. The system depends on the fact that geologic strata



The Sharpe magnetometer, new Canadian instrument embodying a sensitive dip needle in a mounting device.

exhibit selective absorption for radio waves, and that these latter may, with properly chosen frequencies, be transmitted to considerable depths and be reflected back to receivers placed at the surface.

Studies of the utilization of telluric currents for subsurface investigation were continued by the Schlumberger organization, which reports that a known dome in the Gulf of Mexico was well outlined by a surge of telluric current. The same organization continues to make important contributions to well logging, and developments along this line have been presented in papers by Doll and Tixier. These described a new induction logging method, the evaluating of permeability from the resistivity gradient, studies of spontaneous polarization phenomena in shales and sands, and a new method of selective spontaneous polarization logging which gives an accurate determination of the permeable beds. From Pennsylvania State College, George V. Keller reports the development of an improved, shielded monoelectrode for measuring resistivities of thin formations in electrical logging procedures.

Research news in geophysics concerns not only the development of novel devices and new techniques directly applicable to exploration problems, but also the study of broader phases of earth physics. Although the bearing of these geophysical studies on the discovery of natural resources may not now be evident, in the long run they will contribute to that fund of data derived from many sources, which will confer on the exploration scientist more potent tools to use in his searches. A research project has been set up in Toronto to investigate methods and apparatus for determining the temperature and pressure of deposition of vein minerals, factors which have a direct economic application. At Toronto University, studies are being made of heat flow in mines, of geological distribution of radioactivity, and of the gravitational and the magnetic fields of several batholiths. Numerous research projects concerned with the flow of heat within the earth are summarized in Van Orstrand's "Notes on Geothermics," the one most interesting to the mining geophysicist probably being Lovering's work at San Manuel, Ariz. His results have led him to suggest that heat from sulphide oxidation may be as useful in locating sulphide bodies as are galvanic currents. Gravity surveys have been

in operation by the Michigan College of Mines and Technology in an effort to trace major faulting with which copper mineralization is often associated. Companion gravimeter-magnetic surveys have been carried out by Princeton University to trace a concealed thrust fault and escarpment across New Jersey. The idea of exploring for radioactive minerals from the air is the subject of research going on at Pennsylvania State College. The Research Council of Canada is conducting seismic studies, using the Kirkland Lake rock burst as the source shock. An interesting phenomenon, with no immediate bearing on mining, is the subject of a study program at St. Louis University. It is directed towards answering the question of why the lower part of the Missouri River parallels a linear series of magnetic anomalies.

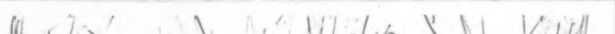
The U. S. Geological Survey program has included aeromagnetic surveys and ground magnetic, electrical resistivity, and gravity surveys in the United States, as well as seismic and geothermal measurements in Alaska. Aeromagnetic traverses were conducted in California and offshore, as well as from California to Denver, and large areas were covered in Michigan and Minnesota in continuation of the survey of iron districts. In Maine, ground magnetic work was carried on to assist in delineating manganese deposits. Resistivity surveys were applied to the search for sand and gravel deposits, for ground water supplies, and in the exploration for vanadium deposits. At Tintic, Utah, gravity and resistivity work were combined to aid in tracing zones of alteration; and at Steamboat Springs, Nev., resistivity, magnetic and spontaneous polarization measurements were carried out in the course of a study of hydrothermal methods of mineral deposition.

Biogeochemical work is coming in for more widespread attention, and at least four companies were working on such projects during the past year. The results are not yet available for publication, but preliminary reports state that they were gratifying. In addition, at the University of British Columbia, research has been going on along these lines and also with the idea of testing water for minute contents of metals.

A promising field of investigation is suggested by reports from Aktiebolaget Elektrisk Malmnetning of the discovery, in Sweden, of deep seated magnetic iron ores. The drilling which revealed these deposits was conducted on weak magnetic anomalies of great extent. These had previously been overlooked because of an abundance of stronger magnetic anomalies from smaller bodies nearer the surface. Magnetic surveying from helicopters is apparently being applied on a large scale in Sweden by Hans Lundberg and by the Boliden Mining Co.

South Africa is the scene of an increasingly intensive application of geophysical methods on a large scale. Mark C. Malamphy & Co. is continuing for the third year a program of prospecting for copper, and in addition is working on investigations for chrome, iron, and coal.

Oscar Weiss' organization has carried out broad programs of geophysical prospecting in Africa, Australia, Canada, and Trinidad. His surveys have been in the search for gold, lead, copper, petroleum, and water. Gravimeter and magnetometer surveys were made in the Orange Free State and the Transvaal, the discovery of a new gold field in the Transvaal being credited to the gravitational work. His organization has introduced modern seismic reflection techniques and equipment into South Africa, which may open up a new stage in prospecting for gold in that country. Resistivity, spontaneous polarization, and gravimeter surveys were carried out in northern Transvaal in a copper area, the results indicating that no one method was definitive, but that useful guides were provided by mapping the pattern of gravity and magnetic anomalies. Attempts to apply seismic and gravimetric work in Trinidad ran into severe difficulties by reason of the peculiar geological conditions there. In Canada, some six square miles surrounding the Buchans mine in Newfoundland were surveyed by gravitational, magnetic, resistivity, and spontaneous polarization observations, and new areas were selected for drilling. He states that he found the most important application of geophysics to be its use for obtaining geological information, mapping rock types, structures, faults and fracture patterns. He sounds a caution against embarking on large surveys without previous small-scale tests, and



"It doesn't sound like uranium to me. It sounds like WJZ."

on the other hand against attempting to treat each problem on paper without first acquiring experience on the ground.

The Geological Survey of India has continued its geophysical program, studying structures in oil fields and coal fields, searching for metallic ores, and investigating water supply problems. Magnetic work was instrumental in the discovery of manganese deposits, and resistivity work proved useful for locating ground water supplies in granitic areas and in the Deccan trap areas but not in the deserts of Rajputana; the electrical technique was also applied to delineating the boundary between saline and potable ground water zones. For measuring bedrock depths at a proposed bridge site, electrical and seismic methods were combined.

Geophysicists operating in Canada report a decline in activity in mining geophysics there, resulting largely from a shift in public interest from mine financing to oil. But in Canada the public is nevertheless potentially interested in mining ventures for, unlike Washington, Ottawa has not yet entirely choked off the sources of risk capital. Exploration interest in the mining fields has shifted away from gold towards the base metals. Lundberg Explorations, Ltd. has been working on base metal and iron exploration in Ontario, and on investigating overburden depths at dam sites in western Canada and on gypsum deposits in eastern Canada. Research by that firm is in progress on an airborne electromagnetic technique. Both air and ground magnetic surveys exploring for sulphide bodies were conducted over a major shear zone in Virginia.

Stanmac Ltd. has been employing a tractor-drawn, low frequency electromagnetic device for prospecting lake bottoms when work can be carried on over the frozen surface. Reports from a survey at Lake Athapapuskow state that some conductive zones were found to be grahpitic shears, but that some showed mineralization of the Flin Flon type.

Koulomzine, Geoffroy & Co. are developing geophysical techniques utilizing drill holes as a means of reaching otherwise inaccessible horizons. They have also been continuing with the usual program of surface magnetic, resistivity, and spontaneous polarization work.

Geophysical Explorations Ltd. has been operating magnetic and spontaneous polarization surveys on eastern base-metal projects, and is utilizing resistivity work to investigate a series of dam sites in western Canada.

Gardiner and Low have been conducting a major magnetic program in the search for chrysotile asbestos deposits in Quebec and Ontario with indications of promising results.

As might be deduced from data cited earlier in this review, there is less to report from the United States, but American-based firms have also been active abroad. Aero Service Corp. conducted airborne magnetometer surveys for minerals over large areas in South Africa, and an extensive one for oil in Mozambique. The same firm was employed by the Ontario Department of Mines to survey a portion of the eastern part of that province. Air-borne magnetic surveys were also carried out for oil and metals exploration in Canada by the Canadian firm, Photographic Surveys Corp.

Sherwin F. Kelly Geophysical Services continued its program in South America, utilizing spontaneous polarization, resistivity, and magnetic methods in Bolivia and Chile, prospecting for tin, lead, copper, gold ores, and searching for ground water supplies. In the United States its most important survey was a study to establish the applicability of geophysical methods to the search for residual limonite ores.

Reports have come in of magnetic and resistivity surveys in the Fredericktown, Mo., area, and of electrical and magnetic work in the Joplin district.

During the past year, two meetings of international interest took place at which geophysics came in for much discussion. One of these was the First Pan American Engineering Congress held in July in Rio de Janeiro, at which T. C. Poulter presented a paper on his seismic technique, the writer presented one on the field of geophysics in problems of water supply, and J. H. Evans of Canada provided a paper on mineral exploration by geophysical methods.

At the end of August, the U.N. Scientific Conference on the Conservation and Utilization of Resources met at Lake Success. During the discussion on mineral resources and water supplies, geophysical methods received a great deal of attention, particularly relating to the possibilities of future mineral discoveries. Contributions were made to this discussion, by the "local boys," such as Paul Foote, Paul Weaver, Hans Lundberg, your reporter, M. King Hubbert, and also by numerous geologists and geophysicists from South America and overseas.

For the future of geophysics and the integration of earth sciences, important evolution is taking place, according to a report by M. King Hubbert. He says, "Another development of long-range significance is the widespread improvement in university curricula and teaching in the fields of earth science. Within the last four or five years the geological profession has arrived at a rather general agreement as to the necessity of the basic sciences of mathematics, physics, and chemistry as a foundation for more complex geological and geophysical thinking. Active steps have already been initiated in a number of universities toward putting these requirements into effect. I think there is no question that these developments are in part a consequence of our earlier AIME discussions on geophysical education."

In preparing this review I must acknowledge my great indebtedness to collaborators too numerous to mention. Were I to cite each one of these "ghost writers" by name, there would be no room left for the review. Suffice it to say that many have generously given information and that the members of the Geophysics Committees of both the AIME and the CIM responded nobly. To all, I must apologize if space limitations have prevented my using their data as fully as would have been desirable and for any errors which I have made in reporting their information.

Industrial Minerals in 1949

by Howard A. Meyerhoff

Nonmetallic rock and mineral products are so diversified that any generalizations regarding the industries based upon them are of doubtful value and can be misleading. They are geared to every phase of the national economy and respond sensitively and immediately to any economic change, but the responses vary with the individual products. They are also affected by political and competitive factors to a degree that is disconcerting and, at times, ruinous to operators, owners, and stockholders of mineral properties. It is not unusual to find these special factors functioning in reverse of general trends insofar as individual products are concerned.

As this summary is being written in the final weeks of 1949, production statistics for the year are not complete, but it is obvious that few, if any, new production records will be set, and that 1949 levels will, in general, be lower than those of 1948. The decline in output is not alarming and reflects in large part the tendency of users, who have been finding sources of supply more dependable, to rely on prompt deliveries rather than on inventories to meet immediate needs. Except for the government's program of stock piling which, insofar as it has worked at all, is of more direct interest and benefit to foreign than to domestic producers, industrial inventories have been further reduced, and the neater balance between production and consumption has freed capital for the manufacturer and has cut down the serious hazard of substantial inventory losses. There are no quantity products and only a few special products that cannot be supplied in quick response to current demands.

Dr. Meyerhoff is secretary of the National Association for the Advancement of Science and a member of AIME.

Normal development of a few nonmetallic industries has been retarded by the government's unpredictable application and irrational interpretation of antitrust laws, and by extension of preferential tariffs to new countries and new products. Synthesis is likewise a potent threat in certain fields, but otherwise it is difficult to make a review of 1949 read much differently from a review of 1948. Changes have been qualitative rather than quantitative, except for a few operations that have been pinched out by the relentless competition that characterizes many of the industrial mineral industries.

Abrasives The assortment of rock and mineral products classified as abrasives has enjoyed the benefits of a brisk market in which only corundum has failed to meet the demand. South African supplies have not

been adequate to meet industrial and stock-piling requirements, and despite the hope that the pending shift from surface to subsurface raw materials in the African deposits will correct current deficiencies, there is as yet no definite assurance that this will be the case. Uncertainties in the South African situation have continued to be an undisguised blessing to the artificial or synthetic abrasive industry and have helped take some of the sting out of government prosecution for alleged antitrust law violation.

Headaches have appeared elsewhere in this field. The Germans have given American tripoli producers a scare by placing what is claimed to be an American type of tripoli on the market. Samples have not been analyzed, nor are reports on performance available, but it is priced low and will give domestic producers tough competition if German claims for its quality are accurate. There is also feverish activity in Arkansas aimed to install finishing equipment for Arkansas novaculite. When the finishing plants go into operation, it seems probable that New England will lose one more industry to the South.

Aggregates Accelerated activity in the construction industries has brought prosperity to producers of raw materials, with sand, gravel, cement, gypsum, and aggregates sharing the benefits. As in 1948, lightweight aggregates virtually acquired glamor as the various types were made the subjects of research, experiment, and practical use. Pumice, pumicite, and "pumicell" lost their standing as abrasive materials and firmly established themselves as lightweight aggregates. The scarcity of domestic vermiculite led to the development of many deposits of perlite in the western states, and some of the hokus-pokus that enshrouded its use disappeared as a few producers declassified the rather simple facts of furnace design for perlite expansion. Clays, likewise, have been found amenable to heat treatment that converts them to lightweight aggregates, and if current experimentation is successful, as it bids fair to be, it is a reasonable guess that clays will replace vermiculite, perlite, and other raw materials in those large sections of the country where clays are abundant and other aggregate base is lack-

PRODUCTION levels below '48 but market stable. Construction materials and fertilizers have good year. New asbestos mine opening in Ontario, research on making lightweight aggregates from clay, geological studies of limestone, new Mexican sulphur deposits high light year.

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Decreasing amounts of eastern phosphates are moving to the far western areas. One reason—the Westvaco Chemical Co's. $4,000,000 phosphorous plant at Pocatello, Idaho, pictured at right.

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ing. Gambling against this probability, private capital has erected, or is constructing, perlite expansion plants in Pennsylvania and Ohio. It remains to be seen whether shipments of native, low-bulk perlite to processing plants in large consuming centers in the East can compete with cheap, locally derived clays, even if the latter yield a somewhat heavier, less uniform, and inferior product.

During the past year or two groundwater has been claimed as an industrial mineral, but only recently has it become clear that industrial mineralists intend to appropriate everything that is free and not nailed down. The latest acquisition is air which, by the process of entrainment, has gained monetary value in cement. Though not strictly speaking a lightweight aggregate, cement that has been manufactured with air entrainment is lighter than ordinary cement, and preliminary tests suggest it may exhibit better wearing qualities.

Slag is still a popular and superior aggregate base, but the recent publication on slag put out by the Bureau of Mines is proof that slag has moved out of the glamor category and into the class of old structural stand-bys.

Asbestos

Asbestos production, which was insufficient to meet 1947 and 1948 demands, received a serious setback in 1949, in consequence of a prolonged strike in Quebec. Johns-Manville operations were most seriously affected as output dropped to less than half 1948 production during the first six months of this year. Although the strike was settled early in July on the basis of a ten-cent-an-hour wage increase and acceptance of four paid holidays a year, there seems to be little prospect of making up the tonnage loss. Approximately 90% of United States imports come from Canadian deposits, hence American manufacturing was hard hit, and the stock-piling program was practically abandoned.

Perhaps the year's most significant development is the announced extension of Johns-Manville operations to Munro township, Ontario, where drilling has outlined an ore body over 1000 ft long and 400 ft wide, with anticipated continuations into two adjacent townships. Production is expected to begin in the spring of 1950 when, according to present plans, 150 men will supply ore to a mill with 50 tons-an-hour capacity. Some progress has been made in the synthesis of asbestos, but commercialization is still remote.

Barite—In 1948, tariff on imports of barite into the United States was reduced from $4 to $3.50. At the same time Maritime Barytes, Ltd., opened newly developed deposits in Nova Scotia. It was not until 1949 that these two events combined to affect the American barite industry. In the course of the year eastern producers were especially hard hit, notably in Georgia and Tennessee. Although the competition has not yet been felt in the Ozark area, Canadian production is a potent threat, especially if Ozark producers find it necessary to go underground for additional supplies of ore.

Construction Materials

The demand for new construction continued strong in 1949, though construction programs faltered briefly and prices firmed during the comparatively short period of uncertainty regarding the economic outlook. The prosperous condition of the construction industries was inevitably reflected in large outputs of clay, sand, gravel, crushed stone, and cement, though as usual the dimension stone and slate producers were not particularly happy with their share of the business. Despite the activity in this field there were comparatively few new developments, except in the lightweight aggregate field, and these have already been discussed. The long-term research program adopted by the Structural Clay Products Institute has not yet progressed far enough to make an impression in the trade, though technological refinements and improvements in the handling and processing of the raw materials could be reported. An impressive list of new pits and quarries and of new plants that went into operation in 1949 could be compiled, but they do no more than reflect a normal and healthy situation in the industry as a whole. Thanks to this condition the full effects of the Supreme Court's decision prohibiting the multiple-basing point system of pricing used by the cement industry were not felt, and valuable time was thereby gained for legislative study of the problem that should result in corrective legislation.

Although gypsum producers enjoyed their share of prosperity in the building boom, the modernization and expansion that culminated in 1948 provided ample mine and plant capacity for all needs, and there has been a moderate drop from the domestic production record of 8,000,000 short tons in 1948, and from the imports of 3,000,000 tons, chiefly from Nova Scotia. Belatedly a few new plants came into production, but current indications are that plant capacity is not likely to be increased until increased demand begins to crowd available facilities.

Diamonds and Gem Stones

Minor events and developments in the diamond and gem stone industries were overshadowed by the death of Sidney H. Ball on April 8. Dr. Ball's long association with work in the Belgian Congo was partially responsible for making him an important figure in this field, and, as if in tribute to him, the efforts to improve production of industrial diamonds in the Congo achieved some success in the course of the year. Demands continued heavy, and price ceilings were reached, hence it may be anticipated that efforts to increase production still further in all African diamond areas will be continued in 1950. Most of the other developments related to gem stones may be classified as progress reports, and the more important of them were in the synthetic category. Definite progress was made in the synthesis of several artificial minerals, with rutile leading the field.

Feldspar and Pegmatite Minerals Except for one new mining operation in the Black Hills of South Dakota and new conversions to the use of flotation in obtaining better feldspar concentrates, rather little that merits reporting transpired in this industry.

A phenomenal increase in the uses of ground mica may be noted, and production remained as high in 1949 as in 1948. Sheet mica, on the other hand, declined, and a comparatively small amount was produced domestically. Indian production also fell off sharply, and reports for the first six months of the year indicated a drop of 40% in the volume of mica exports, and a decline in value from $9,300,000 to $6,900,000 for the period Jan. 1 to June 30, 1949, as compared with the corresponding six months of 1948. Once again Brazil stepped into the breach with a marked percentagewise increase in exports to this country. The large deposits in central Australia, the projected development of which was reported in 1948, had not yet become a factor in the world market, and it is not yet possible to gauge their potential importance. Meanwhile satisfactory progress is being made in the synthesis of mica of the fluorine-phlogotite type.

The production of lithium minerals continued steady, though slow in contrast with output levels reached during the war. There is every prospect that, for some years to come, the bulk of domestic raw material will continue to come from Searles Lake brines, which are also prompting further laboratory study and experimentation. Perhaps the most notable events of 1949 were the presentation of two new lithium compounds to the trade, and the commercial utilization of a little known lithium-aluminum-silicate, petalite, for the manufacture of heat-resisting ceramics. A new development at Cat Lake in Canada is being rapidly pushed and is likely to figure in 1950 production, and lepidolite production in South Africa increased.

Fluorspar—Fluorspar production has continued at approximately the same high level as was reached in 1947 and 1948, when 375,000 tons were produced, 80% of it from the Illinois-Kentucky districts. Here widespread adoption of heavy-media separating techniques was one of the year's noteworthy features. In 1949, interest centered in the new production on Topaz Mountain in the Thomas Range in Juab County, Utah. Discovered and partially developed in 1948, this deposit was opened up more fully, and some ore reputed to run 85% CaF_2 and under 2% SiO_2 has been shipped to the Geneva Steel Co. at Provo, Utah. Situated 60 airline miles from the nearest railway, the product faces heavy transportation costs, and although the development has considerable promise, this serious economic handicap must still be overcome before this new strike and its significance can be fully evaluated.

Graphite—Foreign sources of graphite supply, notably Madagascar and Ceylon, have been somewhat more reliable during the past year, but there is still doubt about their dependability in consequence of internal political unrest. In part for this reason, the study of domestic deposits has continued, and the Bureau of Standards is evaluating domestic graphite, devoting special attention to raw material from the Ben Franklin mine in Pennsylvania. The Bureau of Standards project is designed to produce an evaluation of domestic graphite in comparison with graphite from Madagascar.

Lime, Limestone, and Dolomite—Growing appreciation of the need for limestone and dolomite that will meet rigid compositional specifications has prompted re-examination and chemical analysis of deposits of these rocks in many sections of the United States. State geological surveys have been particularly active in field studies of this kind, and at least one railroad, the Baltimore and Ohio, is preparing an exhaustive report on all the high-calcium and high-magnesium deposits within easy access of its right-of-way. One deterrent to studies of this kind has been the expense of analyzing chemically a suite of samples sufficiently large to be diagnostic. It now looks as if this difficulty may be met by means of spectrographic analysis, through methods that are being perfected by the Indiana Geological Survey. In the industry itself there is little in the way of new developments to report. Considerable interest, however, is being exhibited in the operation of the Fluo-Solids kiln which has been installed by the New England Lime Co.

Drilling, preparatory to blasting, at the Sierra magnesite mine near Gabbs, Nevada.

Magnesium Compounds—Little if any new information is available regarding recent developments in the processing of magnesium raw materials or in the manufacture of magnesium compounds. The increased utilization of magnesite in the northwest, as well as the announcement that Basic Refractories has expanded its operations at Gabbs, Nev., to include the mining and processing of magnesite, as well as brucite, indicates that the competitive battle of costs between sea water and solid minerals is far from settled. Sea water may have obvious advantages from the standpoint of quantity and dependable composition, but the year's developments demonstrate the persistent faith in mineral raw materials with higher Mg or $MgCO_3$ content.

Mineral Fertilizers

Demand for mineral fertilizers has not slackened during 1949, and the world shortage of nitrogen compounds assumed serious proportions, even though the domestic shortage was somewhat alleviated. Any review of the phosphate industry for readers of *Mining Engineering* would be superfluous. Western phosphates were thoroughly discussed at the San Francisco meeting of the Institute in February, and Florida phosphates were given their share of attention at the Regional Fall Meeting of the Industrial Minerals Division in Tampa, Fla. Suffice it to say that demand has been so brisk that several of the operating companies have had to turn to competitors to assist them in filling orders. Western firms have been increasing production to such a degree that decreasing amounts of eastern phosphates are moving into far western areas, and western phosphate is now encroaching upon territory in the midwest that has hitherto been the preserve of southeastern producers. It is obvious that, within a comparatively short time, the industry will take on a distinctly regional cast.

The demand for potash has continued sufficiently promising to have warranted an active exploratory drilling program in New Mexico, and according to year-end reports, the Duval Texas Sulphur Co. and Southwest Potash Co., a subsidiary of American Metals, have staked out large enough underground reserves to warrant the sinking of shafts. There is reason to believe that Duval Texas Sulphur may become a producer during 1950. As this report is being written, the three plants of the Potash Co. of America, United States Potash Co., and International Minerals and Chemical Corp. are closed in consequence of a strike, which started Nov. 19. Immediate settlement is not in sight, and ultimate settlement is likely to result in increased labor costs. Despite the prospect of higher costs and keener competition, the Potash Co. of America and International are both expanding productive capacity.

Quartz of Radio Grade—Demand for Brazilian quartz crystals with piezoelectric properties declined still further in 1949, as did the price. The future of natural quartz crystals in radio communication hangs in the balance, because searches for substitutes have been partially successful, and improved methods of synthesis have already produced crystals of usable size and satisfactory properties, even though the process is not yet ready to pass from the experimental to the commercial stage.

Salt

Supply and demand for salt and other sodium compounds have remained relatively stable in 1949. Developments were rather extensively dealt with in a symposium sponsored by the Industrial Minerals Division at the Mid-Year Meeting of the Institute in Columbus, where the history of the American salt industry, as well as the reserves and developments in New York, the northern Appalachians, Michigan, and Kansas, comprised an entire program. At this late date in the history of civilization, it might seem fantastic to imagine new uses for salt and sodium compounds, yet the Salt Producers Association has recently inaugurated an ambitious research program to study the entire consumption situation and to evolve new uses. One fact appears certain—the Association has plenty of raw material to work on.

Sulphur

In consequence of the marked increase in the variety of uses and in the industrial demand for sulphur there is growing concern about the adequacy of domestic reserves, which may not last as much as thirty more years at the present rate of production. More and more attention is being given to the problem of by-product recovery, and considerable progress was made in this direction during 1949, when several installations designed to recover sulphur from waste gases in oil refineries were constructed. No production from this source has been reported as yet, but it is likely to become an increasing source of secondary raw material as time goes on. For the same reason, developments in Mexico have been regarded with interest. Two, and possibly three, commercial organizations, financed in large part with American capital, have been developing specific properties, and the discovery of new deposits in salt domes in the Isthmus of Tehuantepec, Vera Cruz, and Oaxaca was announced. Mexico has been producing only 3000 tons of sulphur per year, and has been importing approximately 10,000 tons. It is proposed to recover the sulphur by the Frasch system, but the plan to produce 100,000 tons a year, enough to make Mexico an exporting country, has not yet proceeded even as far as the blueprint stage. One new development promises to cut down Argentinian imports for expanding industries. The St. Joseph Lead Co. has installed plant capacity for 36,000 metric tons of sulphuric acid production or the approximate equivalent of 12,000 tons of sulphur. This will cut down the drain on the modest production of the Azufrera del Norte and Sominar, both producers of moderate amounts of native sulphur from deposits of volcanic origin.

Production, Prices, and Labor

Many other notes should be added to make this review of 1949 even reasonably complete. Discovery of a rich deposit of sillimanite in Georgia has been followed closely by testing undertaken by the Tennessee Valley Authority

and the Bureau of Mines. Plans are being evolved to develop the deposit, provided the testing proves successful. Further work on the deposits of kyanite in Virginia is giving definite promise of a quality product. The year has seen further commercial development in the utilization of beach sands in places as far apart as Florida and Australia, for the recovery of zircon and rutile; but domestic production plus imports now exceed demand, and there have been sharp declines in prices that have forced two producers to suspend operations. Milling problems have continued to plague monazite production in the Boise Basin, and interest is currently being displayed in deposits in the Carolinas. Among the rare earths, the year 1949 has seen further development and perfection of the process of ion exchange in producing these elements in pure form. In the first nine months of the year the price of beryl rose steadily, initially in response to an increased demand, but ultimately in consequence of speculation. As demand slackened late in the year stocks were liquidated, and as this report is being prepared, there has been a drop of 10% in price in the United States market, and an even larger decline in Brazil.

Viewed as a whole the industrial minerals industries are in a healthy condition, and there is no evident reason to take a pessimistic view of their development in 1950. However, there are elements of uncertainty that give producers no cause for complacency or overconfidence. On several nonmetallic products the federal government tariff policy is unpredictable, if only because it may be determined either by stock-piling requirements or a wish to increase foreign trade with some specific nation or group of nations. Several companies have antitrust proceedings hanging over their heads, and others have no idea whether or when the legal lightning from the Department of Justice will strike. Too often the legal lights of this department seem more concerned about combinations in restraint of inefficiency than they are with combinations in restraint of trade. And last but not least among the problems faced by the industry is that of mounting costs, with the cost of labor featuring as a rapidly increasing percentage of the total.

In 1949 there have been many strikes in many industries in the industrial minerals category. Chief of them were the strikes in the asbestos mines of Quebec, in the phosphate quarries and pits of Florida, and currently in the potash mines of New Mexico. In the latter the workers are demanding a twenty-five cent per hour increase, yet one reads in the annual report of the International Minerals and Chemical Corp. that, during the fiscal year, July 1, 1948, to July 1, 1949, the average employe at Carlsbad received $4,343.71, compared with $4,063.20 in 1947-48, with a labor turnover of approximately one percent per month. Labor costs as high as these have been partially offset by mechanization that gives management a higher output per man-hour, but mechanization can go only so far.

Before prices are pushed any higher for any reason, whether it be the Government in search of revenue, labor in search of higher wages, or management in search of profit, it will be well to ponder competitive factors. With regard to potash, for example, it was not too long ago that the American industry was struggling for a foothold against German competition. The Stassfurt salts are still there, German labor is cheap, and the threat of German competition is by no means dead, notwithstanding the political partition which that country has undergone. In the laboratory synthesis threatens to put nature to shame in the mass production of crystal products that will compete effectively with natural material if only because of their controlled composition and relative perfection. Presumably it is only a matter of time before these competitive factors will bring about stability in the industrial minerals industries, but they can also bring financial ruin to those operators that do not evolve a flexible cost structure for their products.

The Sulphur Story

At the Texas Gulf Sulphur Co's. operation in Newgulf, molten sulphur is poured into vats (left), blasted (center), and then loaded into railroad cars for shipment.

Foreign Mining Report—1949

THE difficulty of finding new ore bodies, the complexities of patenting them when they are found, and the absence of incentive legislation for exploration have limited mining exploration in the United States mostly to the big companies. This situation, coupled with ECA spending abroad, has caused American capital to look outside our national boundaries for investment opportunities which are further made attractive by some relaxing of restrictions to gain American dollars and patronage.

South America

South American countries, generally speaking, are taking a good share of profits from mining ventures made possible by American money and engineering, but the companies are enlarging their holdings because of the discovery of promising ore bodies and to protect big investments made over the years.

At Chuquicamata, Chile, where oxide copper ore has been mined and treated to the tune of 311,561,688 tons since 1915 by the Chile Exploration Co., sulphide ore has become available as the open pit has increased in depth. A plant for

A SAMPLING of American mining interests abroad indicates: exploration is being pushed, new mines are coming into production, old properties are increasing output, improved methods are being adopted. These trends are indicative of the flow of American capital and engineers abroad.

the treatment of sulphide ore is at present being constructed. Ultimately it will consist of a coarse and fine crushing plant, concentrator, smelter, waste-heat power plant, warehouse and plant offices, 12 miles of railroad, a 10-million-gallon water reservoir, a 45-mile pipe line to bring in 40,000 tons of water daily, and a dam at the intake of the pipe line.

Seven sections of the concentrator and two reverberatory furnaces are expected to be ready to treat 17,500 tons of sulphide ore per day by Jan. 1, 1952. Additional units of the concentrator and smelter will be added as required until the ultimate capacity of 60,000 tons of ore per day is reached. The sulphide plant will be operated concurrently with the existing oxide plant until such time as the oxide ore has been exhausted.

The first sulphide ore will come from the open pit where a considerable amount of this material has been by-passed while mining oxide ore. Plans for underground mining by caving methods are being studied. As the output of sulphide ore from the open pit decreases, the underground mine will gradually be brought into production. The two operations will be synchronized so that the sulphide plant will be assured of a continuous supply of sulphide ore. The changeover from one method of mining to the other will take a period of years.

In conjunction with the construction of the sulphide plant, a large-scale housing program is in progress which will include dormitories to house 680 single men, 544 houses for married workmen and employees, and 44 staff houses; all to be made of precast, reinforced concrete slabs.

The contract for all the construction work, except the pipe line and dam, has been awarded to Foley Brothers, Inc., who have brought in the necessary technical staff and employed and trained a labor force to erect the buildings and equipment. The design and engineering of the project is under the direction of the engineering department of Anaconda Copper Mining Co., of which Chile Exploration is a wholly-owned subsidiary.

Outstanding in exploration is the work being done by the American Smelting and Refining Co. in southern Peru. Two deposits of disseminated low-grade copper ore, commonly known as "porphyry coppers," are being prospected. The properties, known as Toquepala and Quellaveco, lie at elevations of 10,000 to 14,000 ft on the western slope of the Andes, 60 miles and 72 miles, respectively, northeast of the seaport of Ilo. The surrounding country is rugged, arid, and barren; being uninhabited, it has no roads, villages, or towns.

The Smelting Company has established comfortable camps, built over 100 miles of automobile roads, provided water for exploration purposes, and has completed extensive topographic surveys using standard surveying methods for smaller areas of 1 to 20 square miles, and aerial mapping for regional surveys. Careful geological studies and mapping accompanied this first phase of exploration. A drilling campaign has been started and three Bucyrus-Erie L-28 churn drills, and one Sprague & Henwood Diesel-driven diamond drill are at work.

The host rocks of the ore deposits are monzonite porphyries and breccias. Primary mineralization consists of chalcopyrite and some pyrite low in precious metals. Some molybdenum is present. The ore deposits are covered by leached cap rock, and the enriched zone contains copper minerals largely in the form of chalcocite. Sur-

face outcrops at Quellaveco are partly obscured by overburden and partly buried under more recent lavas and tuffs which handicap direct observation.

Exploration has not yet progressed to a point where available tonnages and grade of ore can be estimated with assurance. The indications are, however, that these properties possess mine-making possibilities. It is planned to continue the drilling campaign throughout 1950 and possibly to increase the number of drill rigs employed.

The Chilete mine, near Pacasmayo, a northern Peru property purchased by the company a number of years ago, was the scene of some exploration and preparatory work during the current year. Preliminary plans are being made to prepare this small silver-lead-zinc ore deposit for production when economic conditions warrant.

In the Quiruvilca mining district a great deal of geological mapping and new geological studies have been completed accompanied by an intensive diamond drilling campaign. The copper ore reserves of this property will be maintained as a result of these efforts, and it is hoped that enough lead-zinc ore will also be developed in the southern part of the district to justify an additional mill unit for the treatment of lead-zinc ores.

Howe Sound Co. is one of those organizations that recognizes that mines are where you find them, and it has continued its policy of penetrating isolated and rugged areas by opening the Carmen mine in the Sierra Madre Mountains near Batopilas in the state of Chihuahua, Mexico, in July 1949. Ore is trucked out, over a company-built road, 72 miles north to the town of Creel which is the present terminus of the Kansas City-Mexico y Oriente Railroad. Production at this property is copper-gold ore which occurs in faults as replacement deposits along a fracture zone. Both shrinkage and open-stope methods are being used. The milling plant has a capacity of 500 tons per day of copper-gold ore.

Canada Among the big investors in Canadian mining are the steel companies searching for new sources of iron ore and bringing badly needed dollar credits to Canada.

Exploration of the Quebec-Labrador iron ore concessions by the Hollinger-Hanna interests progressed in 1949 to a point where more than 350 million tons have now been proven. This tonnage, which is expected to be substantially augmented as the drilling program continues into 1950, has already justified serious consideration of the construction of a railroad from the ore bodies to Seven Islands, on the Gulf of the St. Lawrence, and loading facilities at Seven Islands. Late in the year, an important step in this direction was taken by the formation of the Iron Ore Co. of Canada, in which six American steel companies are to participate with the Canadian interests in financing the venture. These are Republic Steel, Armco Steel, National Steel, Wheeling Steel, Youngstown Sheet and Tube, and

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Exploration and development continued on an ever-broadening scale. Here, South African natives are treated to a view of the airborne magnetometer used over their territory by the Aero Service Corp.

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The American Smelting and Refining Co. has built camps, roads, and completed extensive surveys in this barren area of Peru, where two porphyry copper deposits are being prospected.

Hanna Coal and Ore. It is understood that plans are being formulated for marketing the ore at an annual rate of some 10 million tons.

George M. Humphrey, president of The M. A. Hanna Co. of Cleveland, is president of the Iron Ore Co. of Canada. The proposed capital structure of the new company is \$30 million of common stock equity, \$40 million of 3% income debentures, and \$100 million of prior lien bonds. Two thirds of the common stock will be owned by the consuming interest steel companies, and 1/12 each by Hollinger, Hanna, and the two concession companies, Hollinger North Shore Exploration Co. and Labrador Mining and Exploration Co.

Realization of the magnitude of the Quebec-Labrador ore bodies has given much added strength to proponents of the St. Lawrence Seaway. If the Seaway becomes a reality, the Quebec-Labrador ore will become available at all Great Lakes ports via the already existing fleet of Great Lakes ore carriers. Without the Seaway, the ore could still be moved at competitive prices to eastern seaboard points and as far inland as the Pittsburgh district.

Management and operation of the Iron Ore Co. of Canada is to be performed by a new Canadian company to be known as Hollinger-Hanna Ltd., equally owned by the two interests, and undertaking its management responsibilities on substantially the same basis that Hanna and similar companies currently operate iron ore properties in the United States.

After approval by directors, the financing program was recommended in a letter to stockholders of Hollinger North Shore Exploration and Labrador Mining and Exploration from Jules R. Timmins of Montreal, president of both companies. In his statement Mr. Timmins pointed out that the Canadian companies were retaining ample reserves to supply the requirements of the Canadian steel industry, as well as anticipated exportation of iron ore to the United Kingdom and other steel companies in the United States.

At Allard Lake in eastern Quebec, where the Kennecott Copper Corp. and New Jersey Zinc Co. are developing the world's largest ilmenite ore body, the principal activities during 1949 were planning and construction with the view of mining ore by the middle of next summer. Construction of the railroad and port facilities at Havre St. Pierre are progressing according to schedule, and it is expected that the first ore will be shipped over the railroad some time in the middle of the summer of 1950.

Construction is also proceeding according to plan on the smelter at Sorel. The first furnace will be fired up in October 1950. Full-scale operation of the smelter is planned for the summer of 1952. Products of the smelter will be pig iron for Canadian steel industry and TiO_2-rich slag for United States industry.

Another Howe Sound development is the Nor-Acme mine at Snow Lake, Manitoba, 37½ miles north by road from the Wekusko station of the Hudson Bay Railroad. It is approximately 70 air miles east of Flin Flon. Production began in June 1949 following a number of years of preparatory work. During this period a mill of 2000-tons-per-day capacity was completed together with all other necessary buildings for a self-contained operation. In conjunction with the provincial government of Manitoba, a townsite was developed which will be modern in every way. The ore bodies are of the replacement type, and the values are exclusively gold. The ore is being mined by the open-stope method, using horizontal blastholes from raises.

South Africa

Like Canada, South Africa is proving to be favorable for American investment, being without serious restrictions on export and relatively favorable taxation-wise. The same cannot be said for other Pound Sterling areas like India and Australia. Indicative of the trend in South Africa was the September visit of Nicolaas C. Havenga, finance minister of the Union of South Africa, who came to encourage the flow of American investment capital to his country.

O'oKiep Copper Co., Ltd. was organized in 1937 for the purpose of acquiring the assets of South African Copper Co., Ltd. for the amount of \$2,-667,000, which was approximately the out-of-pocket expenditure of the latter company for

The Chile Exploration Co's. operation at Chuquicamata, Chile, where 311,561,688 tons of oxide copper ore have been mined since 1915.

exploration and purchase of the copper properties in northern Cape Province of the old Cape Copper Co., Ltd. That company and its predecessor in interest had operated these mines from 1864 until May 1919, when all operations were suspended because of lack of commercial ore under conditions then existing. According to statistics, the two old companies paid dividends of £4,803,337, due chiefly to production of almost a million tons of 20% ore from the O'oKiep mine, 45,000 tons of 32% sorted ore from the Spektakel mine, and 860,000 tons of 5% ore from the Nababeep South mine.

At the time O'oKiep Copper took over this operation, the mine plant, smelter, and power plant were obsolete, housing inadequate and mill plant and converter equipment nonexistent. Ore reserves were estimated at 10,200,000 tons at 2.45% copper, a gross metal content of 250,000 tons of copper. The late George A. Kervin, general manager, estimated that the property could be equipped with essential plant and facilities and working capital for treatment of 1500 tons of ore per day, and production of 13,000 short tons of blister copper per annum for $4,700,000 in addition to the purchase price, at a production cost as of that date of 6½ cents per lb of refined copper delivered to European ports. Both of these estimates were achieved, and the smelter started up in August 1940.

Through June 30, 1949, 6,359,266 tons of ore were milled averaging 2.45% copper, and 138,822 short tons of blister produced. As of the same date, ore reserves had increased to 11,537,000 tons at 2.67% copper, a gross copper content of 320,000 tons, exclusive of 44,000 tons of copper in oxide ores. Plant capacity as of June 30, 1951 is estimated at 27,000 tons of blister per annum.

An acid plant designed to produce 30 to 40 tons per day of sulphuric acid from pyrrhotite recovered from mill tailing went into operation in October 1949. A leaching plant to treat 500 tons per day of oxidized dump ores should be in operation within twelve months. A 2500-hp steam generating unit using local coal is being installed to replace high-cost foreign Diesel oil. During the past two years, two important ore bodies which do not outcrop have been discovered by the combined application of detailed geology and geophysics, followed up by diamond drilling.

For the fiscal year ended June 30, 1949, O'oKiep Copper Co. made a profit of $2,712,897 after all charges, and had a production cost of 12.1 cents per lb after taxes and all other charges except depletion. Thus O'oKiep ranks among the lower-cost small copper mines of the world.

Tsumeb Corp. Ltd. was incorporated on Jan. 4, 1947 for the purpose of acquiring the assets of Otavi Minen und Eisenbahn Gesellschaft of Southwest Africa from the Custodian of Enemy Property of the Union of South Africa for $4,040,000, and proceeded to rehabilitate this old German property and to provide new power, milling, and housing facilities, on a basis of 1200 tons of ore per day. Capital expenditures on this program through June 30, 1949 totaled approximately $6 million, exclusive of purchase price. At the time of purchase, ore reserves underground and in surface dumps were stated as 1,043,000 short tons averaging 6.6% copper, 17.6% lead, and 10.9% zinc.

Hand sorting of the smelting ore dump was commenced in February 1947, and a sorting and jigging plant of 500 tons daily capacity placed in operation on smelting ore dumps in May 1947. The new selective flotation mill started production in March 1948 on partially oxidized surface dumps. The mine was unwatered to the 20th (1900-ft) level by September 1948, and by June 1949 was supplying the mill with a thousand tons of underground ore per day through limited shaft facilities. During the year ended June 30, 1949, metals accounted for by smelters totaled 30,100 tons of lead, 7150 tons of copper, and 8600 tons of zinc, practically all from mine dumps. During the same period, net profits after all charges totaled $5,032,032. Reasonably assured reserves

as of June 30, 1949 totaled 2,422,000 tons averaging 4.5% copper, 13.9% lead, and 7.4% zinc.

Diamond drilling from the 20th level, and from winze stations 100 and 200 ft below the 20th level, has attained a maximum depth of 730 ft below the 20th level, and has been favorable. A new main shaft was commenced on Nov. 1, 1949, and is being equipped to handle an output of 1800 to 2000 tons from a depth of 3000 to 4000 ft. The program of shaft sinking and development of a 500-ft block of levels below the 20th level will require approximately three years. In the meantime, an internal winze has been completed from the 20th to the 24th level, (500 ft below the 20th level). Connection with the new shaft location, block development, and diamond drilling will be carried on from the 24th level while sinking of the new shaft is in progress.

Mill operations have shown that high-grade lead-copper concentrates and high-grade zinc-cadmium concentrates can be produced from the nonoxidized ores of the lower levels, with excellent recovery of lead and copper. Mill production to date has been geared to the capacity of the narrow-gage (24-in.) government railway. However, Tsumeb now ranks as one of the ten largest lead-producing mines of the world.

New developments at the Mufulira Copper Mines Ltd., Northern Rhodesia, include the adoption of block caving for mining and plans for a refinery to adjoin the existing mine, concentrator, and smelting plant at Mufulira.

Block caving has been successfully applied to two of the Mufulira ore bodies. The ore bodies consist of three superimposed, copper-sulphide-impregnated, quartzite beds varying from 10 to 60 ft thick, with a strike length of from 4000 ft in the upper ore body to 8000 ft in the lower ore body and dipping at 40 degrees and over.

Over a strike length of 3000 to 5000 ft, the two lower ore bodies are separated by a band of low-grade copper ore from 10 to 40 ft and it is to these combined ore bodies that block caving has been applied.

The decision to change from the previous open-stope and pillar, with sand filling, method, to some method of caving or semicaving was made in 1941. Maintaining copper production for the war effort hampered the change-over, and there were doubts as to how much preweakening would be necessary in such hard homogeneous rock to give a product that could be handled on the haulage level and in the shafts without undue difficulty and without too much bulldozing.

Sections of the mine were set aside for experiment and block caving was developed from a system of shrinkage stope and pillar caving through sublevel caving to its present state. The blocks vary in size from 160 by 200 ft to 200 by 200 ft in plan and are delimited across the dip and along the strike on the hanging wall side by a series of crosscuts and drifts spaced at 25 ft vertical intervals. The backs of these drifts and crosscuts are ripped down to a height of 18 ft and are holed through on the tight corner of each block. Failure to delimit the block leads to arching and consequent loss of ore.

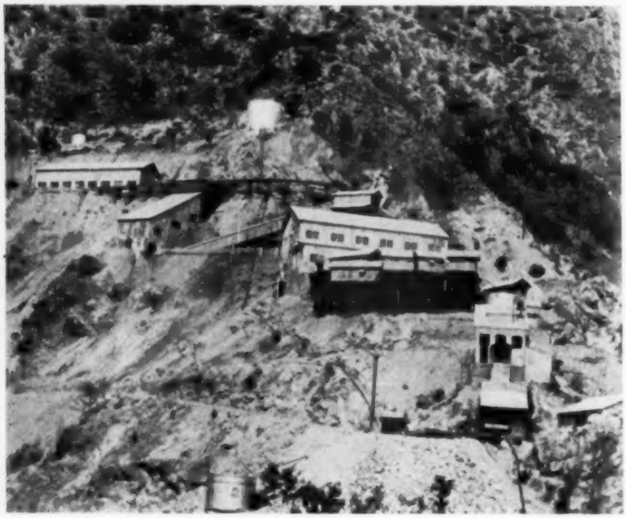
Undercutting is strictly supervised to ensure that no vestige of a pillar is left. Undercutting is done from a series of drifts spaced at 25-ft vertical intervals along the footwall of the lower ore body, and the work proceeds from the top corner of the block on the caved side downwards and towards the solid side, the work being carried out by stoper drills.

Draw is through a series of cones in the footwall, with a spacing of 25 by 25 ft in plan, into slusher drifts where it is scraped by 50-hp slushers into ore passes leading to the haulage level.

Draw control is aided by certain marker beds in the ore bodies, the too-early or too-late appearance of which in the drawpoints is noted, recorded, and acted upon. The draw pattern is checker-board style, *en echelon*, retreating from the fringes of the ore bodies towards the center.

The refinery is still in the design stage and this only to the extent of cathode production. Molten blister will be roughly refined in a 250

A general view of the sulphide plant area, with the beginnings of the Concentrator (in the center) at Chuquicamata. A total Concentrator and smelter capacity of 60,000 tons a day is expected to be reached.



The Howe Sound Co's. El Carmen mine in Mexico's Sierra Madre Mountains, producing copper-gold ore which is trucked 72 miles to the nearest railroad.

ton, 13 by 30-ft Tacoma-type furnace, and 650-lb anodes will be cast on a 22-mould Walker wheel.

The multiple-system tank house will comprise three bays of 396 by 72½ ft, one of which will be the machinery bay. There will be 488 precast concrete-slab tanks lined with 8 lb of 6% antimonial lead. Anodes will be received and cathodes despatched at one end of the house with stripping, starting-sheet preparation, and rod polishing at the other end.

Buildings will be of steel frame construction. The anode department, essentially an extension of the existing smelter buildings, will have Robertson's Protected Metal roof and sides. The tank house will be bricked to working height, with Robertson's Protected Metal to complete the walls and with asphalt-felt covered timber roof. The main working floor will be of acidproof brick in asphalt on concrete.

Tanks for final copper depletion in spent electrolyte will be in the main house as there is no arsenic to provide a hazard. Slimes will be filter pressed, dried, and exported. Refinery capacity will be 36,000 long tons a year, and it is expected to be in operation early in 1952.

Of the 10,000 tons of ore per day being hoisted currently, about 6000 tons come from block caving.

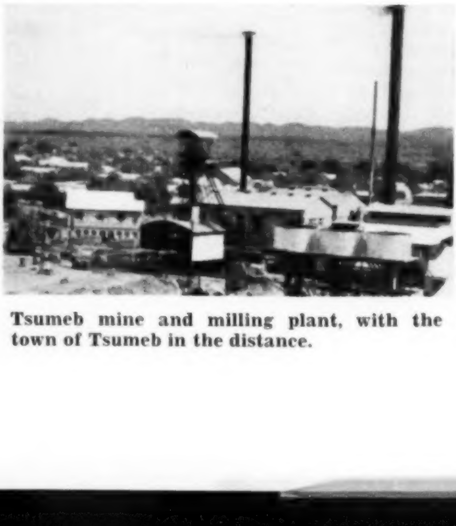
The upper, overlying ore body is mined out prior to caving the two lower ore bodies. In all but a few instances, the thickness of barren separation between the upper and middle ore bodies precludes the block caving of all three ore bodies together.

The mining method used for the upper ore body, and which will in all probability be used for the single ore bodies on the fringes, consists of a continuously retreating series of sublevel stope faces separated by longitudinal crown pillars. Sections of these crown pillars are blasted as the stope faces retreat to allow the hangingwall beds to collapse. The ore is drawn off through the footwall into slusher drifts and thence to an ore pass leading to the haulage. Slusher drifts are spaced at 120-ft intervals along the dip.

All ore passes through a 56 by 72 in. jaw crusher set at 12 in. opening before being hoisted to surface. It is planned to install gyratory as well as jaw crushers underground feeding a conveyor belt 1100 ft long leading to the shafts. The excavations for these crushers and the conveyor tunnel are well advanced.

From this brief survey of mining outside the United States, it can be seen that a world hungry for minerals is receptive to American capital and engineering ingenuity to develop many of its ore bodies.

The editor wishes to thank the following who contributed parts of this article: J. R. Atkinson, R. H. Bauld, C. M. Brinckerhoff, Vinton H. Clarke, George M. Humphrey, H. A. Kursell, J. P. Norrie, and H. DeWitt Smith.



Tsumeb mine and milling plant, with the town of Tsumeb in the distance.

Sinking Star Shaft

at Vanadium, New Mexico

Shaft sinking, usually considered a tough and disagreeable job, has with the development and use of mechanical mucking become a more sought after job by experienced miners. This improvement is no doubt the elimination of exhausting, backbreaking mucking cycles which contributed to the large labor turnover in handmucked shafts. This was apparent in the Star shaft.

by A. J. May

THE Star shaft is near the north boundary of the group of mining claims belonging to the Ground Hog Unit of the American Smelting and Refining Co., near Vanadium, N. Mex. The shaft bins and surface plant are served by a siding from the Atchison, Topeka and Santa Fe railroad, and this factor of railroad transportation influenced the choice of site.

This paper describes the shaft sinking only, and does not cover the surface plant or other parts of the mine or its equipment.

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El Paso Meeting, October 1948.

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Experience with this shaft seems of interest because of the mechanical mucking, good rate of progress, and the costs obtained at the present level of labor and material costs.

The shaft has four compartments, as shown in fig. 1.

Equipment: *Riddell Mucker:* The mucking was done by a clamshell bucket and a Riddell mucker, which, as in other shafts sunk with this machine, consisted of a carriage mounted on axles with double flanged wheels that traveled back and forth on a swinging track, parallel to the long axis of the shaft (fig. 2 to 6). Three air motors were mounted on the carriage; one hoisted the clam, one operated the bucket opening and closing device, and the third moved the carriage along the track. The carriage was designed with guide shoes and could be hoisted to the surface in either skip compartment without trouble (fig. 4). During blasting operations the clam was tied on the rails and the carriage was hoisted up a few sets to protect it from flying rock. No attempt was made to hoist the carriage and clam together lest the clam catch in the timbers.

The track on which the carriage operated was built of extra heavy 6 in. pipe with 1x2 in. strap welded on top for rails. A ½x4 in. angle was welded on the bottom of the 6 in. pipe with a 1 in. round rod welded in the angle for a filler and additional strength. The end or cross pieces of the track which kept the track to gauge, were also made of reinforced, heavy 6 in. pipe and were bolted to the long members on which the carriage traveled (fig. 2 and 3). This section of track was used, instead of heavy railroad rails, for two reasons: (1) this section would bend before it snapped and was much safer for the men in the bottom; and (2) it was a better blasting shield, and protected the timbers better, in fact, only five wall plates were broken by blasting in 1926 ft of shaft, although 150 to 225 lb of 40 pct powder was loaded per round, depending on the ground conditions.

The swinging track was supported by four ⅝ in. hoisting cables anchored to the end plates. There were also four safety cables fastened two to three sets above the carriage, which would catch the carriage if one of the supporting cables should fail for any reason (fig. 7).

Clamshell Buckets: Two clams were used, each of ⅜ yard capacity, both manufactured by Blaw-Knox, Nos. 662 and 663. The No. 663 clam was 4 in. wider and 5 in. shorter than the No. 662, but seemed to dig and load more satisfactorily. It was easier to hoist and lower when it came up for repair. It did not turn over as easily, had less spill

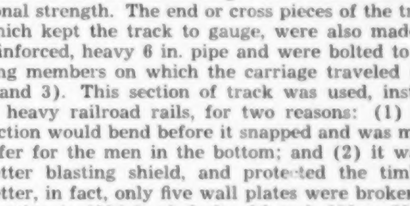


Fig. 1—Plan of Shaft.

when loading, and did not jerk the man holding the tag line rope as badly. Both of these clams were equipped with bottom, corner, and side teeth, although the last named were not used (fig. 6 and 7).

The carriage, rails, and clam as shown in fig. 2, 3, 4, and 6 weighed as follows: carriage, 2720 lb; rails with hangers, 3360 lb; clam No. 663, 2430 lb; for a total weight of 8510 lb.

Sinking Hoist: The hoist used was made by Wellman-Seaver-Morgan and had the following specifications: drums, 60 in. diam; rope (nonrotating), $\frac{7}{8}$ in.; rope pull, capacity of hoist, 8500 lb; rope speed, 600 to 636 ft per min; and motor, 2200 v, 225 hp.

The maximum load handled by the hoist in sinking the shaft 1926 ft was as follows: crosshead,

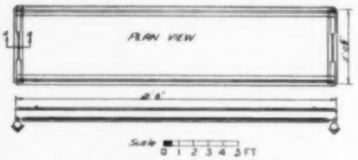


Fig. 2—Side view of track frame for Riddell shaft mucker.

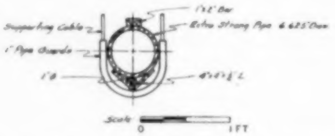


Fig. 3—Section A-A of Fig. 2.

1300 lb; bucket, 1000 lb; load (wet), 3000 lb; rope, 1.32 lb per ft for 1926 ft, 2542 lb; torpedo, clamp, shackles, 300 lb; for a total weight of 8142 lb.

No doubt a hoist with a faster rope speed would have allowed faster sinking, especially the last 600 to 700 ft, as considerable delay occurred in waiting for the bucket to return to the bottom. The mechanical mucker in a shaft is comparable to any other mechanical mucker, that is, to obtain maximum efficiency empty cars or buckets must be kept at the machine with a minimum of delay.

Crosshead: The crosshead used was a Joshua Hendy Iron Works type safety crosshead, now manufactured in a custom shop. This type crosshead was designed so that the safety dogs would hold both the crosshead and bucket in case of rope failure. The crosshead also allowed the cable to travel freely when placed on stops in the headframe for dumping, or near the bottom when loading.

Sinking Buckets: The sinking buckets were 32 cu ft capacity and 40 in. in diameter (fig. 5). In average muck a bucket was loaded in four to six clam loads, which took from 40 to 60 sec. This allowed the crew from 2 to 3 min waiting for the bucket to come back, thus giving them time to pick down and to level off a place to set the next bucket.

Ground Conditions and Blasting: The ground through which the shaft passed consisted of shales, limestones, sills, and dikes, and in places was badly broken. In some sections it was very soft and in others hard. This condition required a change in the number of holes drilled in the round as well as in the location of the holes. In other words, when the ground was soft, the outside rows of holes were kept inside the timber, and when the ground was hard, the holes were placed farther out to keep down the number of plugs necessary for timber room. In hard ground relief cuts were also used. The standard round was a 42 hole V cut using 10 ft steel in the cuts and 8 ft steel in the back part of the round. If relief cuts were necessary, 6 ft steel was used in them.

The electric blasting caps were from zero delay to No. 8 delay. No instantaneous caps were used. The primers were placed as low as possible in the holes to avoid the clams digging a primer from a missed hole.

In extremely hard ground, insert bits were used which greatly increased the drilling speed over regular detachable bits. The average footage drilled per insert bit, with three or four grindings, was 403 ft.

Mucking Operations: It is very important that the track and carriage for the mucker be designed so that the mucker can be operated in the timbers by leaving out the dividers, as was done in this case (fig. 7). This allowed the shaft timbers to be placed near the bottom to take care of bad ground. Care was used when the broken muck piled up above the timbers to insure that the wall plates and end plates were not torn out by the clam.

While the clam worked better in finely broken muck, it also handled large heavy boulders that could not be moved by hand. Breaking large pieces of rock by dropping the clam on them was not good practice because it bent the clam lips so that the teeth would prevent the clam from closing. Then a trip to the surface and shop was necessary to make repairs.

Comparing the old type of sinking by hand mucking with mechanical mucking, the Riddell mucker required more compressed air (at least 600 cfm), more head room, heavier dumping device in the headframe, more rope pull on the hoist, and a faster rope speed. In fact, it would have been economical to place the permanent headframe, hoist, compressor, and other equipment in use during the sinking operations in a permanent setup instead of the temporary setup formerly so commonly used, and used on this shaft.

The clam operator cleaned one end of the shaft of all broken muck which the clam would pick up. The clam usually left from 3 to 5 in. of broken muck, which the shaft crew then picked and mucked by hand into the clam while waiting for the next bucket to return to the bottom. This pro-

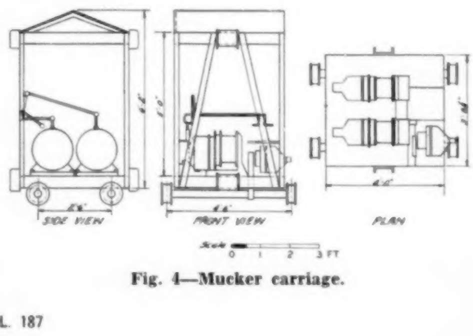


Fig. 4—Mucker carriage.

cedure was followed until the entire length of the shaft had been picked clean, which prepared the bottom for the next drill cycle when the mucking of a round was finished.

In this way only two or three buckets were mucked by hand. The rougher the bottom, the longer it took to clean up. This made the drilling and placing of holes important so that the bottom would have a minimum of bootlegs and break as nearly level as possible.

Timbering and Plumbing: The shaft sets were made of 8x8 in. timber in good ground and 10x 10 in. timber in weak ground. The grade of material was No. 1, or better, Douglas fir, framed at the mill in Oregon according to drawings submitted by the company. Wall plates, end plates, posts, dividers, blocks and wedges were wolmanized-treated after framing to 0.35 lb net retention of wolman salts per cubic foot of timber.

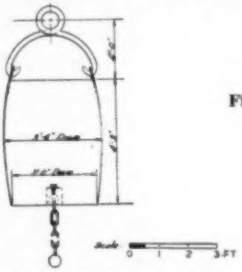


Fig. 5—Sinking bucket, 32 cu ft capacity.

The framing on the first 35 sets received was only fair. However, the framing improved until near the end of the sinking an excellent job was being done.

This class of material, plus the wolmanizing, should give a long life to the shaft timbers, especially in a downcast shaft.

When the framing and treating of timbers at the saw mill before shipment was first discussed, some fear was expressed that the wall plates would warp or shrink. This fear was groundless for it was found by careful handling and piling in the yard that the timber neither warped nor shrank enough to cause difficulty. The timbers were used about as fast as they were delivered which did not allow any great exposure to the sun.

The shaft was plumbed by the engineers every 14 days. This was change day for the shaft crew as they worked 13 days and laid off one. The plumb line brackets were moved down approximately 100 ft each plumbing and were used to establish the line on the next two weeks' sinking operations.

The tolerance was 3/16 of an inch and sets off more than this were relined and reblocked. The 3/16 in. figure was taken because this was as close as the timbers were framed.

Four lines were used in plumbing the shaft: two in the west corners of the west skip compartment; one in the southeast corner of the east skip compartment and one in the southeast corner of the manway compartment (fig. 1).

The line in the east skip compartment was used because of the length of wall plates and to be sure that a bow was not blocked into the 8x8 in. wall plates.

Ventilation: The shaft was ventilated by a 15 hp electrically driven fan, located at the collar of the shaft, blowing through a 20 in. vent tube. This delivered 5000 to 7000 cfm, depending on the depth of the shaft. The smoke was cleared out in from ½ to 1 hr, depending on the depth.

The compressed air motors operating the mucker at times caused fog in the bottom of the shaft which interfered with the vision of the mucker operator and bell ringer. To overcome this condition the vent tube was lowered close to the bottom of the shaft.

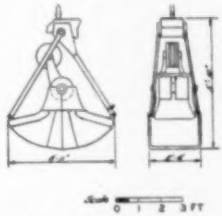
At the 1600 level the shaft connected with the north drift of the Ground Hog mine. From the time this connection was made mine air upcasted through the shaft. The fan was then moved from the collar to the 1600 level and mine air was blown to the shaft bottom. Another connection with the mine was made at the 1800 level, and the fan was again moved down and mine air was blown from the 1800 level to the shaft bottom until the shaft was completed.

Water: On March 29, a small flow of water, about 9 gpm, was encountered 190 ft below the collar of the shaft. The flow soon decreased to about 3 gpm. A water ring was placed at 210 ft below the collar where an electric pump operated by a float was installed and the water was pumped to the surface.

From 190 ft down, small quantities of water were encountered which were pumped by an air-driven sump pump into the bucket and hoisted to the surface. The water from the drilling operations was handled in the same manner. Up to 20 gpm were handled in this way without delay or trouble. During the mucking cycle the water was pumped into the bucket along with the broken muck, and it was seldom necessary to send up a bucket loaded only with water. During the drilling and timbering cycles, the buckets, which held 225 to 250 gal, were pumped full and hoisted.

Below the 1800 level, 100 gal of water per minute was encountered. In three days this flow dropped to 25 gpm. This water was pumped by tandem-

Fig. 6—Clamshell bucket.



driven air pumps to the 1800 level where it was discharged into the mine pumping system.

Below the 1950 station when the head became too high for the sump pumps, an electrically-driven float-controlled pump was installed on the 1950 station. The water from the bottom was pumped by air-driven sump pumps to the 1950 from which the electric pump lifted it to the 1800 level and into the mine pump system.

Sinking Cycle: The sinking cycle varied greatly with the ground conditions. In the better ground where the timber could be kept 20 to 25 ft above the bottom, a complete cycle took about 20 hr and advanced the shaft about 7 ft, which allowed an

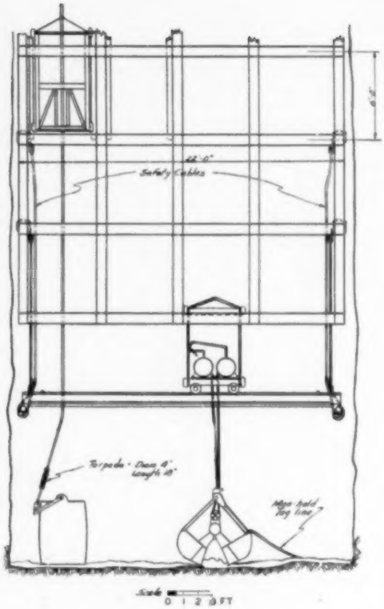


Fig. 7—Mucking operation.

extra set of timber to be picked up every five or six rounds. The cycle was approximately as follows:

	Hour
Drilling	5
Loading	1
Smoke	1
Mucking	7
Timbering	6

In the section where the ground was badly faulted and the timber was carried as close as 6 ft to the bottom, considerably more time was necessary for timbering to stop any sloughing from the walls and to make it safe for the men in the bottom. Also, the mucking operations were slowed up because of the danger of tearing out timbers when the broken muck was over the wall plates and end plates.

Distribution of Shaft Crew: The shaft crew consisted of the following: one foreman (day shift only), one hoistman, one top man, five shaft men, and one lead man in the bottom in charge of the shift.

The foreman worked all day shift. He was on salary and was subject to call at any time day or night.

The hoist man ran the hoist, started and stopped the compressor and looked after the compressor while in operation.

The top man on the mucking shift operated the dump doors, ran the truck which transported muck from the shaft, and dumped the muck out on the patio. On the drill shift he made up primers, collected the bus wires, connecting wires, and tamping sticks, and had the explosives ready to send down when the drilling was completed. During the timbering operations after the wall plates and end plates were hung in place, he sent down the dividers, posts, blocks, wedges, and lagging in that order. When blowing smoke, he oiled the machines, changed the bits and laid out the proper sets of steel ready to go down when the next drill cycle started.

During loading operations, three men loaded the powder and primers into the holes and three tamped.

When timbering, one man blocked in each of the four corners. A plumb line was hung in the center of the south wall plate, which allowed the fifth and sixth man to line and block the center compartments. The men always drilled and timbered in the same corners. In this way it was possible to supervise blocking and drilling.

The crew was split as follows during mucking operations: one bell ringer, one Riddell operator, one operating the tag line in the bottom, and one leveling off a spot to place the next bucket and scaling down the wall. Two men usually stayed up in the timber working on odd jobs, such as manways, ladders, platforms, and vent lines. If there was no other work for them they went to the bottom and helped to bar down, to clean the bottom, and to get ready to drill.

When possible, timbering was done right after blasting, as this only required the bottom to be cleaned up once for the drill cycle.

The shaft men when possible, ate lunch during the smoke cycle, moving their lunch period forward or back in order not to lose any time. They also moved the wall plates, end plates, posts, and so on, to the collar ready to lower as soon as the smoke cleared.

Accidents: Table I gives the lost time accidents showing the number of days lost and location of accidents:

No permanent disability resulted from any of these accidents, except the loss of one tooth in accident number 6. The most severe accidents, as indicated by the time lost, occurred on the surface, and not in the shaft.

Many precautions were taken to avoid accidents.

When an empty bucket was lowered below the collar the hoistman blinked the lights twice signaling the bell ringer that the bucket was on its way

Table I. Lost Time Accidents

Accident No.	Place	Days Lost	Description
1	Shaft bottom	6	Rock in bucket rolled on finger.
2	Surface	29	Leg cut by power saw.
3	Surface	38	While loading crosshead on truck, crosshead slipped and fell on foot.
4	Surface	40	While unloading 10x10 timbers, winch line slipped and timber fell fracturing foot.
5	Surface	22	Lifted bucket of drill bits into shaft bucket and strained left side.
6	Shaft bottom	13	Rock fell from jacket set, striking hat and knocking head against jackhammer, cutting face and loosening teeth.
7	Shaft bottom	1	Clam snapped shut on rock which splintered and particle lodged in eye.

Table II. Sinking Rate

Month	Sinking, Ft	Timber, Ft	Stations	Loading Chutes	Bearer Sets	Concrete Rings	Water Rings	Spill Pocket	Remarks
1948									
Feb.	75	60							Hand mucking
March	112	108							Riddell mucker installed 3/3
April	168	164			1		1		Larger hoist and larger compressor installed
May	208	212							
June	211	210				1			
July	218	218			1				
August	215	222	1200 ft		1				
Sept.	115	106	1400 ft						
Oct.	170	161		1	1	1			
Nov.	118	128	1600 ft			1			
Dec.	157	160	1800 ft	1	1	1			
1949									
Jan.	115	116	1950 ft	1	1				
Feb.	47	59						1	Sinking completed Feb. 10
Total	1926								

down. If the bell ringer answered, the hoistman slowed up at the crosshead stop, spotted the crosshead, and then lowered directly to the bottom without any further signal. If the bell ringer did not answer the hoistman's signal, the bucket was stopped at the crosshead stop until a signal to lower to the bottom was given.

The bell ringer was stationed on the set directly above the mucker carriage and rang all signals. He had complete view of the mucker operator and the men in the bottom. The bucket had to pass him on the way down.

The bell ringing job is the most unpopular job of the whole operation because of the discomforts of the exposed position and the necessity of being alert at all times.

A good alert bell ringer can keep the accident rate low on the mucking cycle more than all the rest of the crew, as he has a complete view of the ground and all equipment and men involved.

Another reason for the low accident rate is the fact that there has not been a change in the shaft crew personnel since June 1948. This crew as of May 15, 1949 is still intact and will move over to No. 5 shaft, which is to start sinking immediately.

Sinking Rate: Table II shows the sinking rate per month along with the stations, loading chutes, bearer sets and concrete rings.

The time required to complete the stations, and so on, when converted to sinking brought the rate of sinking to approximately 207 ft per month, after the Riddell mucker and large hoist were installed.

Costs: Table III shows the cost per foot of shaft, excluding costs of shaft stations, permanent air lines, pump column, and power cables.

These costs are presented, not as an example of low costs, but as actual performance in shaft sinking during the year 1948, when labor and material costs have been at a very high level.

Table III. Cost of Shaft-sinking Operations

	Labor[a]	Supplies	Other	Total
Preparatory Work:				
Temporary change house (Housing, attendant, heating supplies)	$ 0.65	$ 0.62	$ 0.01	$ 1.28
Sinking headframe and bucket dump	2.45	0.34	0.07	2.86
Sinking hoists and housing	2.56	10.82	0.24	13.62
Sinking pump equipment	0.12	0.36	0.01	0.49
Special sinking cages, buckets and equipment	1.31	6.32	0.01	7.64
Temporary electric air compressor	0.49	0.15	0.01	0.65
Concrete collar	0.74	1.30	0.10	2.14
Preparatory work	$ 8.32	$ 19.91	$ 0.45	$ 28.68
Shaft Sinking:				
General	$ 1.82	$ 3.53	$ 1.59	$ 6.94
Drilling and blasting	22.41	5.24		27.65
Explosives		7.96		7.96
Mucking	32.89	1.62	0.07	34.58
Truck and dozer (waste disposal)	0.17	0.42	2.12	2.71
Timbering and concreting (includes guides)	26.06	56.03		82.09
Framing shaft sets and lagging at mine[b]	6.08			6.08
Hanger bolts	0.95	3.86	0.01	4.82
Air and water lines in shaft[c]	0.90	1.69		2.59
Hoisting	12.60	0.91		13.51
Lighting in shaft	0.27	0.46		0.73
Ventilation in shaft	0.28	1.38		1.66
Power	0.07	0.24	3.80	4.11
Signals in shaft	0.47	1.28		1.75
Pumping water	0.59	0.90		1.49
Supervision	9.45	0.02	0.21	9.68
Engineering	0.80	0.08	0.03	0.91
General office accounting	0.73			0.73
Royalty on Riddell mucking machine			3.08	3.08
Shaft sinking	$116.54	$ 85.62	$10.91	$213.07
Total preparatory and sinking	$124.86	$105.53	$11.36	$241.75

[a] Labor at mine. [b] Most shaft sets were purchased, framed and treated, but a few sets were framed at mine. [c] Not permanent air and water lines.

Practical Dust Control

in Metal Mines

by W. C. Williamson and J. L. Shugert

The paper covers the different phases of dust dissemination in the Butte mines and methods of its control. Dust inspection and reporting same are taken up in detail. Methods of dust and dust counting techniques with their associated problems are discussed. Effects of different methods of dust depression are demonstrated under controlled conditions.

DUST control is receiving considerable attention today by most companies as is evidenced by the many articles, papers, and books written on the subject. Most of the larger mining companies have given this subject close study and have established standardized methods of control.

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San Francisco Meeting, February 1949.

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Permissible Limits: The question of permissible dust limits has been considered by medical committies and various national conferences. Dr. Lanza, of the Metropolitan Life Insurance Company, Dr. Leroy U. Gardner, of the Saranac Laboratory for the study of Tuberculosis, and Dr. Pancoast, of the University of Pennsylvania, have been members of these committees. A statement included in reports of some of these committees is as follows:

Concentrations to which the dust must be induced in order to be safe have not been absolutely determined. There is evidence that a concentration of more than five million particles per cubic foot of a highly siliceous dust is dangerous. Therefore, it may be stated that it is desirable to avoid counts of more than five million particles of dust containing free silica to a high percent in working places.

Table I gives the safe limits adopted by several state industrial codes.

Table I. Safe Limits of Dust Concentration

State	Limit Million Particles Per Cu Ft
California	
Silica (less than 10 pct)	50
Silica (10 pct to 50 pct)	10
Silica (more than 50 pct)	5
New York	
Free silica less than 10 pct by weight of rock formation	100
Free silica more than 10 pct by weight of rock formation	10
Oregon	
Silica (over 40 pct)	5
Silica (20 to 40 pct)	10
Silica (10 to 20 pct)	20
Wisconsin	
15 million particles, under 10 microns in longest dimension, per cu ft of air, when the quartz content of the dust is 35 pct, variations in free silica content will make proportional inverse changes in this standard.	

Close attention to dust concentrations has been given to mining operations, since these operations are frequently carried on at considerable distances

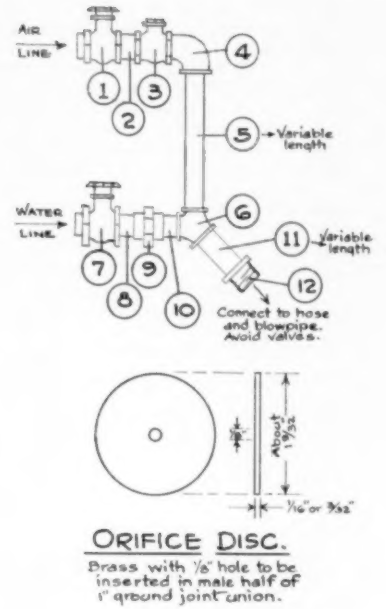

Fig. 1—Compressed air and water blowpipe assembly for use in freeing skip pockets. No. 1-7, 1 in. Mueller valve; No. 2, 8, 10, 11, 1 by 2 in. common pipe nipples; No. 3, 1 in. Crane (disc) check valve; No. 4, 1 in. malleable street ell; No. 5, 1 x 6 in. common pipe nipple; No. 6, 1 in. malleable Y; No. 9, 1 in. ground joint union (gem); No. 12, 1 in. air hose spud-thread variable. Fine thread. Coarse thread Emma-O'Girl-Leonard.

from fresh air sources, and often in areas lacking normal air circulation. Favorable progress has been made in the prevention of silicosis, and with the proper use of modern equipment it is possible today to keep concentrations of dust well within safe limits.

Main Hoisting Shaft: Since the main hoisting shaft frequently serves as the source of fresh air for underground workings, it is necessary to maintain a clean, clear atmosphere around the collar. This can be effected by sprinkling and oiling or hard surfacing the mine yard and surrounding areas.

Conditions in the shaft may be responsible for contamination of the main air supply. If the shaft is dry, water sprays at several points should be turned on during hoisting periods to keep the shaft timber damp, thus preventing dust that has settled on the shaft timber from being stirred up by the movement of skips and cages or by spilled rock. Small mist sprays may be used over air takeoffs from the shaft.

Overloading of skips should be minimized to stop spillage, thus avoiding dust resulting directly from falling rock. Measuring pockets with air operated gates helps prevent overloading. Dust caused by loading skips from pockets may be kept down by using sprays on the chute gates to cover the rock as it flows to the skips. Skip loading platforms should be kept clean and should be wet down periodically. If blowpipes are used in freeing chute hangups, water should be introduced into the compressed air. This can be accomplished by connecting the water line to the air line just ahead of the hose connection, and providing a check valve in the air

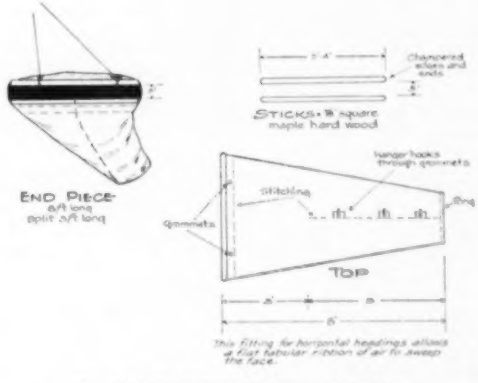

Fig. 2—Fan tube discharge end piece.

Size of Ventube, In.	Length of Sticks, In.	Orifice Opening, Sq Ft	Area of Ventube, Sq In.	Ratio of Area
12	22x5	110	113	1:02
16	30x5	150	201	1:34
21	38x5	190	346	1:82

line and a 1/8 in. orifice in the water line to regulate the amount of water introduced (fig. 1).

Shaft stations on the various levels should be open and clean, and should be washed occasionally to prevent any buildup of material which might contaminate the intake air. The top of the skip pocket into which cars are dumped may require water sprays. If waste passes are located on the

stations, the same precautions should be observed as at skip loading pockets. For cleaning car bottoms, a long handled metal blade is preferable to a compressed air blowpipe, but where the blowpipe is used, water should be introduced into the compressed air in the manner previously described.

Working Places: Locomotives and trains passing through a haulageway decrease the net cross-sectional area, causing an increase in air velocity. This leads to the lifting of dust from the sill in dry areas.

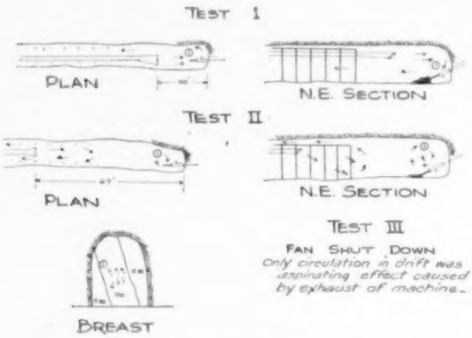

Fig. 3—Air circulation during experimental tests.

To eliminate such action the haulageways should be wet down. Mist sprays, used in higher velocity air flows, and occasional wetting down with a sprinkling hose are both effective. Water connections should be available at convenient intervals. Calcium chloride has been used to maintain a damp condition but is not always satisfactory as it eventually is covered by dust and has to be applied repeatedly to remain efficient.

Opening and closing of ventilation doors also causes temporary high air velocities. The immediate area around a door should be kept damp. Some mines place salt on the sill to hold moisture at such places. Repeated applications are necessary as previously stated.

Temporary dust contamination in air from working places should be traced to its source and the cause ascertained. Most frequent cause for this condition is movement of dry rock. Corrective measures should be applied at once. If dust occurs at raise or stope chutes, where loading causes high dust concentrations, sprays should be used.

Level Headings: Headings (crosscuts, drifts and laterals) should be supplied with sufficient ventilation to remove gases and dust from the active work area. If blowers are used to force air to the working face, they should be located in the best available air in the vicinity, which would contain no return air. Air is generally carried to the working place by flexible tubing; it is recommended that the end of the tubing be not more than 25 ft from the face, and as near the back as possible. A special end piece, such as shown in fig. 2, discharges a narrow ribbon, 5x30 in. for 16 in. fan tubing of high velocity air near the back of the heading. The return air will be at the bottom, so that the miner is not subjected to the stream of air striking his body. This scheme is decidedly advantageous when ventilating air is cold.

Persistent effort is required to secure compliance with these regulations because harmful airborne dust is invisible to the naked eye and, also, because there is little knowledge as to the increase in dust concentrations at the working face that may result from neglect in observing these precautions. The effect of distance from the working face to the end of the ventilation tubing was, therefore, determined experimentally under controlled conditions. Discharge of air from the end of the tubing was made through an oblong opening that caused the air to flow in a flat, tabular stream that struck the face near the back and swept drilling dust downwards and out along the floor line (fig. 3). Table II presents the results of an experimental test in a drift.

Table II. Results of Experimental Dust Tests in a Drift

Distance from Breast to End of Flexible Tubing, Ft	Volume of Air for Ventilation, Cu Ft per Min Through Tubing	Depth of Hole Drilled, Ft	Dust Concentration, Millions per Cu Ft of Air	Remarks
20	2,600		0.29	No activity
20	2,600	3.8	7.93	Drilling. Much chuck splash.
20	2,600	3.9	8.79	Drilling. Much chuck splash.
67	2,300	4.2	24.90	Drilling. Air circulating in closed swirls. Misty.
67	2,300	4.3	29.75	Drilling. Air circulating in closed swirls. Misty.
67	No ventilation	4.5	23.08	Drilling. Air circulating in closed swirls. Misty.
67	No ventilation	4.5	32.06	Drilling. Air circulating in closed swirls. Foggy.

The following notes describe conditions under which the above test was made:

Hard ground. Good supply of drill water. Automatically rotated drill. All holes were collared before the tests and were upward cut holes drilled at angle of about 30° above horizontal.

For effect of distance from working face of end of ventilation tubing during drilling, see fig. 3.

All dust samples were taken at the same place, at the breathing zone of man drilling. The average for the 20 ft distance is 8.36 millions, for the 67 ft distance 27.33 millions, and with no ventilation 27.87 millions. It is, therefore, evident that when the end of the tubing is allowed to remain at a distance of 67 ft from the breast, dust conditions are no better than they would be if no ventilation equipment were supplied, and are above safe limit.

In this connection, it is also interesting to note the work of G. E. McElroy, of the U. S. Bureau of Mines, who has shown that no matter how much the volume of air discharged from a ventilation tube is increased, the distance at which it is effective in creating air motion in a drift remains practically constant.

After establishing ventilation, the working area including face, back, sides, and muck pile, should be wet down to prevent dust rising from the barring down and mucking operations. If dry sections are exposed in the course of mucking, these should be wetted again. A dry working place should be wet down before timbering.

Although nearly all drilling today is done with wet drills, it is not generally realized that use of an

insufficient amount of water can result in high dust concentrations. It is usually advisable to use as much water as can be put through the machine and drill steel. Manufacturers of rock drills increased the size of water tubes used in these machines to help combat dusty conditions. Collaring holes dry should be discouraged, as this practice introduces a dust hazard of the highest order.

Blasting should be done under cover of a compressed air and water blast, sometimes called a "fogger." This is turned on after spitting the round, and shut off immediately after the blast. It should be located within 35 ft of the face, close enough to cover the blast location with mist. The effect of this device in freshening the air is clearly shown by fig. 4 which presents test data obtained under similar conditions with and without the use of the air and water blast. The average of four dust samples taken during the period indicated in the curves showed a 99.6 pct decrease in dust concentration when the air and water blast was used.

Raise Headings: Raises are also dead ends and should be treated the same as sill headings. Each raise should have its individual blower, of the same capacity as that used for sill headings, and located with the same care.

Wetting down the working area and the manway of a raise should be the first operation after a blast or at the beginning of the shift, if this can be done with safety. Barring and cleaning down which follow are then not apt to raise dust.

At the time of drilling, the vent tubing should be brought up so as to introduce fresh air above the drill staging. This insures a clean sweep of the back and allows exhaust with little recirculation.

The use of a compressed air and water blast in a raise, vastly improves conditions for the workmen. The device converted for this purpose, as shown in fig. 5, will freshen the air in a raise so that a miner can return to the place with safety 15 min after a blast. It can be used in either of two ways, spiked in place to jet upward toward the back, or spiked to jet downward into the chute if the back is bad.

Stopes: Stopes with facilities for through ventilation should receive as careful attention as places requiring auxiliary ventilation. Care should be taken that manways to levels above and below the active mining area are open sufficiently to allow free circulation. The movement of air through manways can be facilitated by the use of grates rather than solid landings. Wetting down these air courses is especially important when they are located alongside working chutes and this may require use of fine sprays. Vibration, set up by the action of rock passing through a chute, can cause dust that has accumulated on timber to be picked up by the air stream unless the manway is kept damp.

Material being slushed, mucked, or cleaned down in a stope should be kept damp enough so that no dust is visible in the air. At most mines today, wet stope filling is used because it has been found that wet fill consolidates better than dry. Where dry waste is used, it is essential to provide a water hose at the point where waste is dumped into the fill raise. Cars can also be cleaned with this hose.

Stopes not having through circulation of air should be provided with auxiliary ventilation as in any dead end working place, and the same precau-

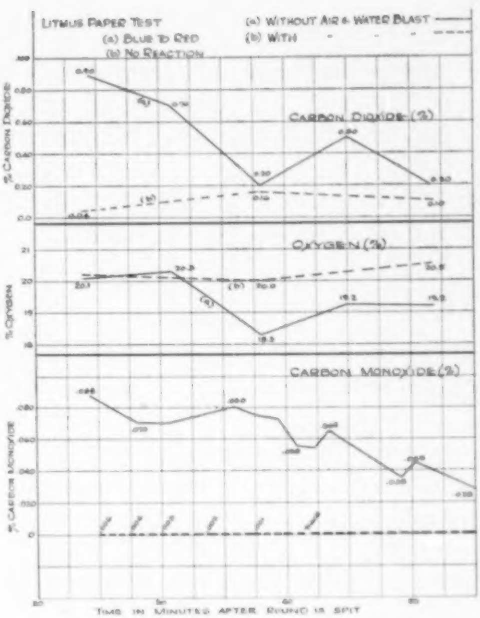

Fig. 4—Environment after blast in heading.

tions should be taken in the various operations, including use of a compressed air and water blast during blasting.

Repairmen should keep their working places wet down just as thoroughly as any other, in order to prevent contamination of air by dust.

Standardization: Where a large group of mines is operated under one management, as in the Butte district, it is both practical and desirable to standardize procedures for dust control. Miners move from one mine to another, and, having become familiar with the practice at one mine, do not have to learn new practices elsewhere in the district. Most of the equipment has been standardized, including fans, fan tubing, air and water blasts, and sprays. Methods of installing and using these have also been standardized as far as practicable.

Differences in temperature may require differences in the application of ventilation equipment. For instance, a man working in a warm place will be more likely to place the fan tubing in proper position for an effective "sweep" of air over the working face than a man in a cold place. The man in the cold place is prone to leave the ventube at an ineffective distance from the face. This tendency can be overcome by using less air and introducing it close enough to the work for a definite circulation of fresh air at the face. Some mines in high altitudes and cold climates find it necessary to heat the air used for ventilation purposes.

Dust Survey Methods: In the Butte district, ventilation engineers usually make routine inspection trips in company with the shift bosses. Such trips

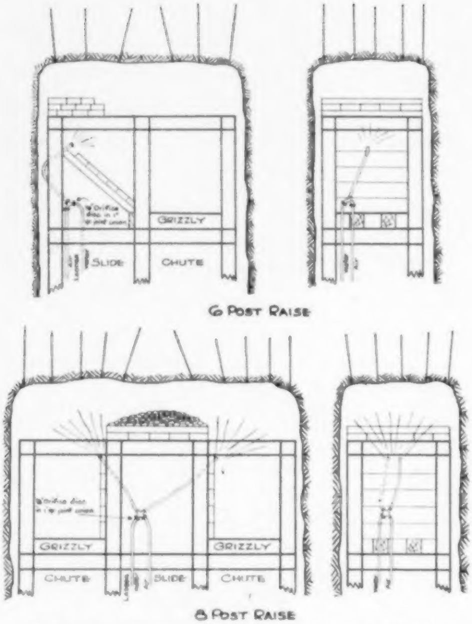

Fig. 5—Raise compressed air and water blasts.

serve to acquaint the inspectors with the working problems and conditions. The areas requiring further attention are readily recognizable and a spot check or a return visit can be made as desired. It is well to leave a daily report of findings with the mine foreman for his information. The time between inspections should not be allowed to exceed two months.

The midget type impingers used for sampling have U. S. Bureau of Mines approval. The constant volume type pump is gaining in favor over the constant pressure type. They combine ease of carrying with speed of setting up. It also makes it possible to obtain a sample representing any desired period of time which may cover several high or low peaks of dust concentration. A measure of the average exposure is obtained with this instrument by an unweighted sample.

By the use of some of the other instruments such as the Konimeter, the sample is not taken throughout a period of time but may record only a high or low peak of dust concentration in one sample. This necessitates many samples for the same result obtained with one midget impinger sample.

The sampling equipment should be kept in good order to avoid errors from this source. The pump should be calibrated frequently. Also, as may be seen from the paper* by Richardson, Warren and Williamson, it is well to number and calibrate the individual impinger tubes.

* Presented before National Safety Council Meeting, Chicago, Oct. 1945. "Some Sources of Error in Dust Sampling Work Done by the Impinger Methods."

This paper, also, calls attention to the importance of cleaning the glassware thoroughly, especially the tubes which are difficult to clean.

Another source of error in sampling is demonstrated by test on sampling in high velocity air. From this, it can be seen that when velocities exceed 750 ft per thousand, an elbow is necessary to bring the tube in line with direction of flow.

U. S. Bureau of Mines approved practices of particle counting are followed. Counting cells should be accurate in depth of one mm, and settling time of all cells should be practically identical.*

* Presented before National Safety Council Meeting, Chicago, Oct. 1945.

The counts with necessary remarks are reported to the mine operators and management with recommendations for corrective measures.

For thorough coverage, a general dust survey (as contrasted with spot coverage) should be made at less frequent intervals. In this survey, every working place should be sampled, covering every phase of the operation. By compiling the results of this sampling, a figure representing average dust concentration or worker exposure may be obtained. If this dust concentration is appreciably below the safe limit as determined by the U. S. Public Health Service for the type of dust encountered, the dust control measures existing in that operation may be considered adequate.

General: There is considerable variance in the opinions of experts as to the importance of the different phases of dust which causes silicosis. Some feel that, if dust contains no silica, it is not harmful no matter what the size or concentration.

Others feel that, if the dust is not small enough to get in the alveoli of the lungs, it cannot cause silicosis no matter what the composition or concentration may be. At present, there seems to be some agreement as to size that is harmful which is anything smaller than 3 microns.

Still others feel that no matter what the size or composition may be, the dust is not harmful if the concentration is low enough. Since there is no known practical method of controlling particle size or composition of dust in metal mines, it is evident that all efforts must be directed towards keeping the dust concentration below the established safe limit.

In the above discussion it has been shown that there are three particularly effective weapons for keeping down dust concentrations; ample ventilation, wetting down, and compressed air and water blasts.

In experimental tests where the amount of ventilation has been increased, it has been established that the effect is nearly proportional, that is, if a volume of dusty air is diluted by an equal volume of clean air, the dust concentration of the combined air is only slightly higher than one half that of the original dust laden air.

Thus the role of ventilation in reducing dust concentration is of major importance.

The human factor must also be given the attention that it deserves, as cooperation between workmen and management is necessary in order to apply an effective program for dust control.

In conclusion, it may be said that if a proper dust control program is put in force and administered by responsible men with full cooperation of the workmen concerned, no harmful dust condition should exist.

Measurement of Equilibrium Forces between an Air Bubble and an Attached Solid in Water

The forces acting between a small rod, one end of which was made water repellent, adhering to a much larger air bubble in water were measured. An equation is deduced which correlates these forces and the influence of each force is discussed. The importance of the size of bubbles in a flotation cell is emphasized.

by T. M. Morris

A SEARCH of the literature reveals that no measurements have been made of the forces acting between a small solid particle whose surface is hydrophobic, and an air bubble to which the solid adheres, both immersed in water. Analyses have been made of the forces acting to support a greased solid on the surface of water, and the forces acting to cause a solid, whose surface is hydrophobic, to adhere to an air bubble in water. The latter analysis is often incomplete, however, because the internal pressure of the bubble has been neglected. It will be demonstrated that the internal gas pressure is not a negligible factor when dealing with bubbles of the size encountered in flotation.

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This paper is the result of work done for part of a doctor's thesis at the Missouri School of Mines and Metallurgy.

A study of the forces acting between an air bubble attached to a large flat surface is informative. It must be borne in mind, however, that this is not the condition present in a flotation cell, where the particle is small compared to the size of the bubble. The bubble is allowed to spread to its maximum contact angle on a large flat surface in the first case, whereas in the second case, the spread of the bubble is limited to the surface of the small particle which is presented to the bubble.

Kabanov and Frumkin[1] studied the forces acting to cause adhesion of bubbles of hydrogen to a large surface of mercury, which served as an electrode in a dilute sulphuric acid solution. The force acting to hold the bubble to the mercury surface was found to be the vertical component of the surface tension between hydrogen and the sulphuric acid solution. The forces tending to cause the bubble to separate from the mercury surface were found to be: (1) the force exerted due to the internal pressure of the bubble acting upon the area of contact between the bubble and the mercury surface, and (2) the buoyant force of the bubble minus the hydrostatic force acting at the base of the bubble.

These investigators photographed bubbles that were just on the verge of separating from the mercury surface. From these photographs, they measured the contact angle between the mercury surface and the tangent to the hydrogen-solution interface at the point of contact between bubble and mercury surface. They calculated the volume of the bubble and the internal pressure of the bubble. The equivalence between the upward acting and downward acting forces was remarkable.

Wark[2] pursued an investigation similar to that of Kabanov and Frumkin, and at the same time. His deductions verified those of Kabanov and Frumkin. He also considered the conditions present in flotation and was aware of the effect of the internal pressure of the bubble. Further, he proposed several conditions under which a small solid particle would adhere to an air bubble in water.

In 1922, Edser,[3] an English physicist, made the following statement. "It must be remembered that no particle could float stably, but for the possibility of variation of the contact angle, for if this were a constant, a slight tilt would inevitably cause the particle to sink." Wark criticized this statement, maintaining that the contact angle does not vary. The experimental data to be presented indicates that Edser was correct.

Experimental Procedure: Briefly, the experimental procedure was as follows. A bubble of air was generated in distilled water. A rod of known diameter, one end of which was water repellent, was attached to this bubble. The weight of the rod was measured. The internal pressure of the bubble was measured with a manometer. The hydrostatic head from the surface of the water to the bottom of the rod was measured. The angle between the horizontal projection of the end of the rod and the tangent to the bubble at the circle of contact be-

tween rod and bubble was measured. This will be denoted as θ hereafter. The forces acting upward and downward, between rod and bubble were then evaluated.

As shown in fig. 1, the bubble of air was generated by displacement of air by water, from a stoppered bottle. A square glass jar contained the water in which the air bubble was generated. The glass tee terminated in a manometer, as shown.

The glass jar was placed on a metallograph bench. The magnified image of the bubble and attached rod, and the surface of the water in the jar was observed on a ground glass plate. The manometer was placed in a lantern slide projector and its magnified image was thrown onto a screen.

Various sizes of bubbles could be generated by changing the size of the glass tube (a), which fitted into the short length of the tee by means of a piece of rubber tubing. The size of bubble was more closely controlled by means of an adjustable screw clamp at (b).

A tracing of the image on the ground glass plate of the metallograph was made, using onion skin paper. Simultaneously the difference in liquid levels of the limbs of the manometer image was measured. From the tracing, the angle θ and hydrostatic head were measured, as well as the diameter of the rod and of the bubble tube.

The magnification factor for the metallograph was obtained by measuring the outside diameter of the tip of tube (a), with a micrometer, and also measuring the width of the image of the tip of this tube on the ground glass plate. The ratio of the two measurements gave the magnification factor obtaining in each test. The magnification factor of the lantern slide projector was obtained in a similar manner by measuring the outside diameter and the outside diameter of the image of the manometer tube. The tracing appeared as shown in fig. 2.

In order to check the accuracy of the pressure measurements, La Place's equation was used.

$$\Delta P = \gamma \left(\frac{1}{R_1} + \frac{1}{R_2}\right) \qquad [1]$$

where ΔP = pressure differential across a gas liquid interface in dynes per cm^2 and γ = surface tension in dynes per cm, and R_1 and R_2 are the principal radii of curvature of the interface at the point where the pressure differential is measured, both expressed in centimeters.

A bubble was generated in distilled water. No rod was attached to it. The radius of curvature of the bubble at its nadir was measured. The hydrostatic head from the surface of the water to the nadir of the bubble was measured. The difference in levels in the limbs of the manometer was measured. Acetone, rather than water, was used in the manometer because the difference in levels was greater than if water had been used, and also this liquid responded more quickly to pressure changes than did water, because of its lower surface tension. Since a differential manometer was used to measure internal pressure, atmospheric pressure was not taken into account in measuring hydrostatic head.

The radius of the bubble at its nadir is difficult to measure accurately. A pair of calipers was used and by trial and error the radius of the line passing through the nadir of the magnified image of the bubble was measured. The calipers traced the

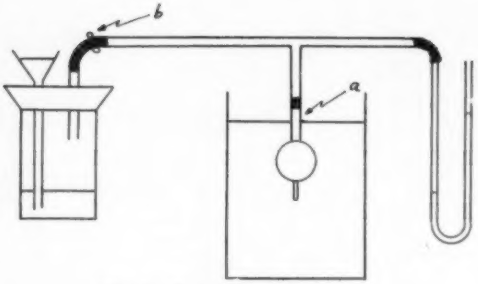

Fig. 1.—Experimental apparatus.

curve for at least a half inch on each side of the nadir. This fit was considered satisfactory.

Applying Eq 1, substituting 72 dynes per cm for the surface tension of distilled water at 26°C and $R_1 = R_2$ since the radii of curvature are equal at the nadir, we can calculate values of ΔP and check against observed values of ΔP, Table I.

Table I. Sensitivity of Measurements

Test	Diam of Tube(d),Mm	Pressure,Mm Water		R_1, Mm	ΔP, Dynes per Cm^2	
		Manometer	Hydro. Head		Calc.	Obs.
1	9.10	8.37	5.72	5.74	251	259
2	9.10	12.25	8.65	4.12	350	352
3	4.28	21.30	10.30	1.34	1,075	1,077

The density of the acetone used in the manometer was 0.79. This factor was used to convert millimeter of acetone to millimeter of water. The magnification factor for the metallograph camera was 9.78 and that for the lantern slide projector was 10.24.

These tests indicate that the apparatus was sensitive enough to measure the pressure differential between the outside and inside of the bubble.

Attachment of Small Rods to Bubbles: In the first series of tests, glass rods of varying length and di-

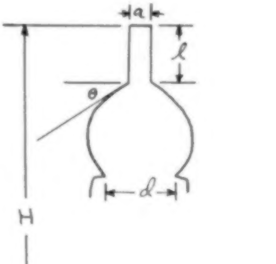

Fig. 2 — Tracing of system bubble particle.

Table II. Glass Rods Used

Test	Millimeters			Weight, Grams	Mm H_2O		θ	Forces, Dynes				Sum	
	a	*l*	*d*		*H*	*M*		Wt.	Down	Up	S. T.	Down	Up
1	0.83	9.40	3.30	0.0150	19.10	15.50	45	14.75		1.90	13.25	14.75	15.15
2	0.41	10.10	7.25	0.0033	16.90	9.70	12	3.23		0.93	1.92	3.23	2.83
3	1.05	6.82	7.25	0.0120	13.95	9.92	22	11.75		3.45	8.80	11.75	12.25
4	1.05	6.82	3.30	0.0120	16.30	15.40	30	11.75		0.76	11.85	11.75	12.61
5	0.88	9.67	3.30	0.0184	19.10	14.45	49	18.00		2.80	15.00	18.00	17.80
6	0.70	11.90	3.30	0.0118	21.80	15.20	30	11.60		2.41	7.80	11.60	10.21
7	0.70	4.10	3.30	0.0042	13.10	15.70	20	4.10	0.96		5.36	5.06	5.36
8	0.70	4.10	7.25	0.0042	11.45	9.87	12	4.10		0.61	3.34	4.10	3.95
9	1.37	7.12	7.25	0.0261	14.50	8.57	32	25.60		8.60	16.50	25.60	25.10
10	0.83	7.18	3.30	0.0092	16.85	15.30	23	9.00		0.82	7.32	9.00	8.14
11	0.83	7.18	7.25	0.0092	14.20	9.62	20	9.00		2.43	6.40	9.00	8.83

ameter were used. The ends of the rods were dipped into molten paraffin and cooled. This end was pressed against a clean glass slide in order to give a plane surface at the end of the rod.

In the second series of tests, copper rods of constant diameter, but varying length, were used. The ends of the rods were filed and then rubbed with crocus cloth in order to give a reasonably plane surface. These rods were cleaned in ethyl alcohol, followed by distilled water, and then dipped into a dilute nitric acid solution and again washed in distilled water. For the first lot of tests in this second series, the rods were placed in a ½ pct solution of sodium aerofloat in water, and in the second lot of tests a ½ pct aqueous potassium ethyl xanthate solution was used. In both cases the rods were removed from the conditioning solutions and attached to a preformed bubble of air in the glass jar. A small stainless steel wire holder was used to attach the rods to the bubble.

Data Obtained: Table II lists the pertinent data concerning the first series of tests, in which glass rods were used. Table III lists the data pertaining to the tests in which copper rods were used. In Table III, the first seven tests are those in which sodium aerofloat was used. The last three tests are those in which potassium ethyl xanthate was used.

In both Tables II and III, *a*, *l*, *d* refer to the measurements denoted in fig. 2. *H* is the hydrostatic head from the surface of the water to the bottom of the rod. *M* refers to the manometer reading. Under the heading Forces, Dynes, the column marked Down refers to the difference between *H* and *M*, expressed in dynes, acting downward. Conversely the column labeled Up refers to the difference between *H* and *M*, expressed in dynes, acting upward. The last two columns are the sum of all upward and downward acting forces. The column labeled S.T. refers to the upward force due to the vertical component of the surface tension between air and water. The value 72 dynes per cm was used, since the temperature of the distilled water was 26°C.

Discussion of Data: The difference between upward acting and downward acting forces in the several tests is small and can reasonably be ascribed to experimental error. More refined measurements would undoubtedly show closer correspondence.

The bubble covered the whole surface at the end of the rod. In some cases it was difficult to draw the tangent to the bubble at the point of contact with the end of the rod. This was especially the case when the angle between the tangent and a horizontal line was large, since the bubble necked down and was on the verge of giving a reentrant angle.

The series of tests show that the four forces considered account for the equilibrium maintained when a conditioned solid adheres to an air bubble. The angle θ varies as the weight of the rod varies, in order to maintain equilibrium.

Contact Angle and Flexibility: The value of contact angle measurements made in the usual manner is very important because such measurements tell us the maximum contact angle which can be obtained with a given collector, such as potassium ethyl xanthate.

The static contact angle is the angle measured in the tests listed in Tables II and III. The static contact angle cannot exceed the maximum contact angle for a given collector, otherwise our contact angles measured in the usual manner do not mean anything.

Static conditions do not prevail in a flotation cell. Centrifugal forces are generated which tend to in-

Table III. Copper Rods Used

Test	Millimeters			Weight, Grams	Mm H_2O		θ	Forces, Dynes				Sum	
	a	*l*	*d*		*H*	*M*		Wt.	Down	Up	S.T.	Down	Up
1	0.70	1.35	2.07	0.0045	11.08	16.45	25	4.40	2.04		6.65	6.44	6.65
2	0.70	1.35	3.30	0.0045	11.65	14.65	21	4.40	1.18		5.65	5.58	5.65
3	0.70	3.20	7.25	0.0107	13.52	12.80	43	10.52		0.27	10.80	10.52	11.07
4	0.70	3.20	3.30	0.0107	13.70	16.60	50	10.52	1.10		12.20	11.62	12.20
5	0.70	1.95	7.25	0.0065	12.95	13.10	25	6.37	0.06		6.60	6.43	6.60
6	0.70	1.95	3.30	0.0065	12.65	16.50	30	6.37	1.46		7.90	7.83	7.90
7	0.70	1.95	2.50	0.0065	11.30	15.80	31	6.37	1.65		8.10	8.02	8.10
8	0.70	2.84	7.25	0.0099	13.00	12.85	36	9.65		0.06	9.45	9.65	9.51
9	0.70	2.04	7.25	0.0071	14.10	14.65	26	6.90	0.21		7.06	7.11	7.06
10	0.70	1.41	7.25	0.0049	14.10	14.90	19	4.77	0.39		5.15	5.16	5.15

crease the "weight" of the particle. Therefore the contact angle must be greater than the static contact angle for that particular particle bubble system, in order to allow equilibrium to be maintained between bubble and particle. If the centrifugal force is so great that a contact angle greater than the maximum possible for the collector used, is demanded, disruption of the bubble particle system must occur.

Now, the greater is the difference between maximum contact angle and static contact angle, the greater is the ability of the bubble particle system to withstand disruption. This difference is herein referred to as the flexibility of the system. For example, if the static contact angle for a given system is 50°, and if the maximum contact angle is 60°, the degree of flexibility is low, namely 10°, and such a system could not withstand disruptive forces to the extent that a system whose static contact angle is 20°.

Gaudin and Vincent[4] reported that the maximum contact angle decreases as the concentration of collector decreases. Thus, the degree of flexibility of the system is decreased. The coarse particles are affected more than the fine particles, because the contact angle required for static equilibrium is less for fine particles than for coarse particles for a given sized bubble. This is demonstrated by the tests cited in Tables II and III.

The flotation of fine particles of gangue (in addition to the fine gangue mechanically carried over in the froth) can be understood in view of the forces acting. If partial activation of the gangue is obtained, the maximum contact angle would be small when such a partially activated particle reacts with the collecting agent. Coarse particles of gangue will not adhere to an air bubble because the maximum contact angle and hence degree of flexibility is not large enough.

Sutherland[5] has discussed the disruptive effect caused by the greater initial acceleration of the bubble compared to the particle and also the disruptive effect of the viscosity of the fluid.

Spedden and Hannan[6] have photographed the path of bubbles passing through a dilute pulp of galena in water. The disruptive effect of bubble oscillation can be clearly observed.

It is the writer's opinion that Edser meant that the "working" contact angle changes to achieve stability, but not that the maximum contact angle changes.

Size of Bubbles: In order to show the magnitude of the effect of size of bubble and hence internal pressure on the degree of flexibility of the bubble particle system, an equation is deduced. Fig. 3 shows the bubble and particle in liquid.

Let h = distance from surface of liquid to midpoint of bubble, in cm.
r = radius of bubble, in cm.
l = length of rod, in cm.
a = diameter of rod, in cm.
w = weight of rod in air, in dynes.
P = internal gas pressure of bubble, in dynes per cm².
θ = static contact angle.
γ = surface tension of liquid gas interface, in dynes per cm.
ρ = density of liquid, in dynes per cm³.

Then, equating upward and downward acting forces, when static equilibrium obtains:

$$P\frac{a^2\pi}{4} + w = a\pi\gamma \operatorname{Sin}\theta + (h + r + l)\,\rho\frac{a^2\pi}{4} \quad [2]$$

Eliminating the factor $\frac{a^2\pi}{4}$, and simplifying:

$$P - h\rho + \frac{4w}{a^2\pi} = \frac{4\gamma\sin\theta}{a} + (r + l)\,\rho$$

But $P - h\rho = \Delta P_0$ = difference between internal and external pressure of the bubble at its midpoint, and $\Delta P_0 = \gamma\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$, where R_1 and R_2 are the principal radii of curvature of the bubble at its midpoint, or

$$\gamma\left(\frac{1}{R_1} + \frac{1}{R_2}\right) + \frac{4w}{a^2\pi} = \frac{4\gamma\sin\theta}{a} + (r + l)\,\rho$$

and

$$\frac{4}{a}\gamma\sin\theta = \gamma\left(\frac{1}{R_1} + \frac{1}{R_2}\right) + \frac{4w}{a^2\pi} - (r + l)\,\rho$$

$$\sin\theta = \frac{a}{4}\left(\frac{1}{R_1} + \frac{1}{R_2}\right) + \frac{w}{\gamma\pi a} - \frac{(r + l)\,\rho a}{4\gamma} \quad [3]$$

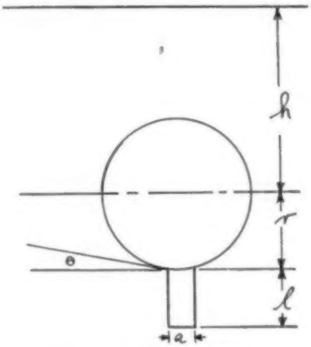

Fig. 3—Bubble and particle in liquid. Static equilibrium.

In order to check Eq 3 we may use the data pertaining to test 1 in Table III. Fig. 2 is the tracing of the image of the bubble and particle used in this test. The magnification factor was 9.20. $R_1 = 1.52$ mm, and $R_2 = 1.72$ mm.

Then,

$$\sin\theta = \frac{0.70}{4}\left(\frac{1}{1.52} + \frac{1}{1.72}\right) + \frac{4.40}{7.2\,\pi\,(0.70)} - \frac{(1.52 + 1.35)}{(4)\ (7.2)}\left(\frac{980}{1000}\right)(0.70)$$

$$\sin\theta = 0.427$$
$$\theta = 25^\circ\ 15',$$

compared to the observed angle of 25°.

For the purpose of comparison we may compute the value of θ if the internal pressure of the bubble had been neglected.

$$w\left(\frac{7.9}{8.9}\right) = \pi\,a\,\gamma\sin\theta$$

$$\sin \theta = \frac{w\left(\frac{7.9}{8.9}\right)}{a \gamma \pi} \qquad [4]$$

$$\sin \theta = \frac{7.9}{8.9} \; \frac{4.40}{(0.70)\ (7.2)\ \pi}$$

$$\sin \theta = 0.25$$

$$\theta = 14^\circ\ 30'.$$

The ratio $\frac{7.9}{8.9}$ modifies the weight of the copper rod in air, to that in water, taking 8.9 as the density of copper.

Let us assume that we have a particle of galena in the shape of a rod, the diameter of this rod being equal to 0.15 mm, and the length being equal to 0.15 mm. Its weight in air is then equal to 0.019 dynes. Let $\gamma = 72$ dynes per cm. The variation of θ with change in the size of bubble would then be, according to Eq 3.

Table IV. Variation of θ with r

Static Conditions				Acceleration of 50 g	
r Mm	Sin θ	θ	b, Dynes	Sin θ	θ
1.00	0.075	4°18′	4.10	0.349	20°26′
0.50	0.152	8°45′	0.51	0.430	25°29′
0.25	0.304	17°42′	0.064	0.580	35°27′

In Table IV, b is the buoyancy of the bubble, expressed in dynes. The right hand side of the table shows what θ would have to be if the difference in acceleration of bubble and particle were 50 times the acceleration of gravity.

For the purpose of comparison with the data in Table IV, let us calculate θ if the effect of the size of bubble and hence internal pressure of the bubble is neglected. According to Eq. 4:

$$\sin \theta = \frac{6.5}{7.5} \; \frac{0.019}{(0.15)\ (7.2)}$$

$$\sin \theta = 0.0049$$
$$\theta = 17 \text{ min.}$$

Further, if we assume a difference in acceleration between the bubble and particle of 50 times that of gravity, $\theta = 14^\circ\ 15'$.

It can be observed that the influence of the size of bubble and hence internal pressure of the bubble is very important. Thus for a given sized particle, the value of the static contact angle θ increases as the size of bubble decreases as shown by Table IV, and Tables II and III. The difference between the maximum contact angle possible for a given collector and the static contact angle is greater the larger the bubble; this means that the degree of flexibility is greater. The previous discussion has pointed out that the greater the degree of flexibility, the greater is the chance for a bubble particle system to withstand rupture caused by centrifugal force, oscillations of the bubble, and other factors, in a flotation machine.

Now this does not mean that only large bubbles are desirable in a flotation cell. Experience has shown that a large number of bubbles are desirable for best results. Thus, the greater the number of bubbles the greater is the number of particles attaching to them per unit of time, and hence the greater is the rate of flotation. For a given cell volume, and a given air intake per unit of time, the smaller the bubble, the greater the number of them.

The size distribution of bubbles should be governed by the size distribution of particles present in a cell. For the largest size of particle, small bubbles which demand a large static contact angle would not be desired for the reasons already discussed. But for the smaller sized particles these small bubbles would not demand a large static contact angle and hence would be very desirable because of their number.

However, the bubbles which are so small that they demand a large static contact angle when attached to the smallest size particles are undesirable because the degree of flexibility is small. If a flotation cell is used in which disruptive forces are extremely small, these small bubbles may be desirable.

A comparison can be made between the size distribution of bubbles in a flotation cell and the size distribution of balls in a ball mill. We know that large balls are required to crush the largest pieces of solid. But this does not mean that we want all large balls. Experience has taught that a graded ball charge is desirable, the size distribution of balls depending upon the size distribution of the particles of solid to be ground. Those balls which are so small that they do no useful work are not desired. They take up space that could be occupied by larger balls which do useful work. They are an inevitable result of the wearing down of a ball charge and have to be accepted. Similarly in a flotation cell, the very small bubbles have to be accepted in creating the size bubble desired.

Speeding up the impeller in a flotation cell results in smaller bubbles, similar to a finer ball charge in a mill. A point may be reached where the percentage of bubbles that are too small to be useful is greater than the percentage of small useful bubbles. That is a problem for the design engineer.

Summary

1. The forces acting between an air bubble and an attached solid in static equilibrium have been measured.

2. The importance of the flexibility of a particle bubble system is discussed.

3. The importance of the size of bubble has been emphasized.

4. An equation has been deduced that correlates the forces acting between a gas bubble and an attached solid particle.

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Northern Rhodesia Mufulira Copper Mines Limited

Grinding Tests

on Conical Trunnion Overflow and Cylindrical Grate Ball Mills

This paper gives details of the results of careful testing carried out on two types of ball mills, conical trunnion overflow and cylindrical grate discharge, on identical ore. The object of the test work was to determine which ball mill was the most economical to install for future extensions to the Mufulira concentrator.

by Jack White

MUFULIRA Copper Mines, Limited, conducted tests on the concentrator in 1942 to determine which type of ball mill, that is, Conical Trunnion overflow or Cylindrical Grate discharge, produced the greater quantity of finished product at the lowest cost.

All the data which follows applies to Mufulira ore and to the particular degree of grinding produced with the classifiers installed at Mufulira concentrator.

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Test Procedure: The test was carried out using ball mills No. 1 to 9 (conical trunnion overflow) as the standard with which to compare No. 10 (cylindrical grate discharge mill). The conical trunnion overflow ball mills are 10 ft diam by 72 in., and the cylindrical grate discharge mill is a No. 99. Each mill runs in closed circuit with a Dorr type DSFX classifier 8 ft wide by 30 ft long. The feed is considered as being identical to all ten units. The figures for the test were derived as follows.

Dry Tons Milled: For No. 10 unit (cylindrical grate discharge mill) this figure was taken from the ball mill weightometer, which was corrected for error, and then for moisture content. The weightometer was checked twice a week during the test, and the error did not exceed 3 pct at any time. The moisture was obtained from a 24 hr moisture sample taken by the ball mill operator hourly, and placed in a closed bucket. The sample was cut where the conveyor drops the feed into the ball mill chute. The Mill Sampling Department made a daily moisture determination on this sample. To obtain the dry tons on units No. 1 to 9 the No. 10 figure was deducted from the month's dry tons milled figure, which, in turn, was taken from the crusher weightometer tons corrected for weightometer error and moisture. All tons reported in this test are short tons of 2000 lb.

Ball Mill Hours: This was taken daily from the Shift Boss reports giving actual running hours for each unit.

Screen Analyses: *Coarse Heads (Ball Mill Feed):* The monthly composite coarse heads screen analysis, done by the Mill Sampling Department, was used for the minus 200 mesh in the feed to the mills.

F. X. Classifier Overflow: The ball mill operators took an hourly 24 hr sample of the overflows of units No. 1 to 9. This was a hand sample, but cut with a special cutter, and is believed to be very reliable. On No. 10 unit, an hourly 24 hr sample, and an hourly shift sample were cut in the same way. These five samples were split, filtered, and dried by the Research Department and were then wet screened on a 200 mesh screen. The average of the three shifts samples on No. 10 unit had to check the 24 hr sample within 1.5 pct to be acceptable. A weighted composite was cut each day from both 24 hr samples, and at the end of each month it was screened as follows:

Wet screened through 325 mesh, the plus 325 then screened on a rotap for 15 min through 65, 100, 150, 200, and 325. This was done in duplicate. All splitting, drying, and screening of samples was done by one of the Mill Research staff, to insure accuracy.

F. X. Classifier Overflow Densities: These were taken from the Shift Boss reports. Densities were taken by the ball mill operator every hour.

Circulating Loads: These were taken a number of times during the test both by direct method (weighing a measured portion of classifier rake sand, and deducting moisture) and by calculation using the formula:

$$Y = \frac{X(b-a)}{a-c}$$

Where X = tons per hour original feed.

Y = tons per hour classifier sand.

a = percentage of minus 100 mesh in ball mill discharge.

b = percentage of minus 100 mesh in classifier overflow.

c = percentage of minus 100 mesh in classifier sand.

Ball Loads: No. 10 unit was charged with 75,000 lb of balls at the beginning of the test and an effort was made to keep mill amperage constant. This met with some success, but on several occasions, by inspection, ball level was found to have dropped. For the last month's test, the consumption figure for the preceding months was used as a guide in adding balls, and this resulted in a very steady ball load. From the average level, as measured when the mill was down, it was calculated that the average load was 72,000 lb.

Power Figures: The power meter on No. 10 unit was read every morning at 7 a.m. and the power consumed for the preceding day calculated. The month's figures, the sum of these daily power figures, corrected for meter error, were used for the No. 10 mill. For the mills No. 1 to 9, the monthly power figures as provided by the Electrical Department were used. This figure was obtained by monthly meter readings, instead of daily, and was subjected to meter error correction.

Screen Analysis of Ball Mill Feed: A typical screen analysis of coarse heads (feed to all ball mills) is given in Table I.

Table I. Screen Analysis of Coarse Heads

Screen Size		Per Cent
Plus	0.525 in.	0.4
	0.371 in.	9.8
	3 Mesh	15.2
	4	8.3
	6	8.6
	8	5.8
	10	8.9
	14	5.5
	20	4.5
	28	4.3
	35	5.0
	48	2.9
	65	2.9
	100	4.7
	150	2.4
	200	2.3
	325	1.7
Minus	325	6.8
		100.0

Duration of Test: The investigation was carried out over a period of seven months, from June to December, 1942, inclusive. The September test is not included because of the time down for lining the No. 10 mill, and changing the drive motor. Tests for June, July, and August are thought to be less accurate as regards power figures than those for October, November, and December, because during the former months it was discovered that the No. 10 ball mill motor was somewhat defective. The summary of the test is, therefore, split into two halves in Table II and III.

Table II. Summary of Test

	June July August		Oct. Nov. Dec.	
	Mills No. 1 to 9	Mill No. 10	Mills No. 1 to 9	Mill No. 10
Horsepower	385	463	379	450
Per cent —200 mesh in classifier overflow	50.55	52.44	52.46	52.03
Dry tons per ball mill hour	31.85	35.48	31.68	37.55
New tons —200 mesh per ball mill hour	13.04	15.20	14.00	16.32
Kw-hr per dry ton milled	9.00	9.74	8.92	8.92
Kw hr per ton—200 mesh produced	22.04	22.78	20.32	20.55
Grinding balls used in lb per ton	2.88	3.68	2.78	3.53
Liners (gross) used in lb per ton	0.43	0.63	0.43	0.63

Table III. Screen Analysis of F. X. Classifier Overflows

		June July August		Oct. Nov. Dec.	
Mesh		Mills No. 1 to 9	Mill No. 10	Mills No. 1 to 9	Mill No. 10
Plus	65	6.0	4.5	6.4	5.0
	100	14.1	12.9	13.3	13.9
	150	15.3	15.3	14.3	15.1
	200	13.8	14.3	13.8	14.3
	325	9.6	10.1	9.5	9.8
Minus	325	41.2	42.9	42.7	41.9
		100.0	100.0	100.0	100.0

	Conical Trunnion Overflow	Cylindrical Grate
Average per cent solids in F. X. Classifier Overflow	24.7	21.9
Average circulating load, per cent	420.0	460.0
Ball load in mills in short tons	36.0	36.0

Observation: (1) To obtain a comparable grind it was necessary to overflow the F.X. Classifier at 2 to 3 pct less solids with the cylindrical grate mill than with the conical trunnion overflow mills.

(2) There appeared to be little difference with regard to ease of operation. Overloads on the conical trunnion overflow mills were reflected immediately in the sand load on the classifier, whereas the cylindrical grate mill overloaded internally. This condition was indicated by a drop in amperage and a definite decrease in mill noise.

(3) From the maintenance point of view, the cylindrical grate mill was much more difficult to inspect, and required more time to reline.

Conclusions: (1) The cylindrical grate mill with a ball load of 72,000 lb had a one sixth greater grinding capacity than a conical trunnion overflow mill with the same tonnage of balls, on Mufulira ore.

(2) Consumption of grinding balls was 27 pct greater for equal tonnage ground in the cylindrical grate mill.

(3) Consumption of liner steel at 0.63 lb per ton (gross) was 32 pct higher than for the conical trunnion overflow at 0.43 lb per ton (gross).

(4) In terms of power cost per ton of finished product produced, the cylindrical grate mill required from 1 to 3 pct more power than the conical trunnion overflow, on Mufulira ore.

(5) The cylindrical grate mill produced about 2 pct less oversize (plus 100 mesh) than the conical trunnion overflow, because the classifier was run at a lower density, but at equal densities the cylindrical grate grind was inferior to the conical trunnion overflow.

(6) Work done by either type of mill was directly proportional to power input.

(7) Considering power costs approximately equal, the cylindrical grate ball mill produced more finished product at the expense of considerably more steel consumption.

Radioactivity

at the Caribou Silver Mine, Boulder County, Colorado

by G. Carman Ridland

A program of exploration for radioactive deposits, conducted in 1945 in the well-known mineralized areas of the Front Range, Colorado, was rewarded with the discovery of pitchblende in a dump at Caribou Hill. The presence of pitchblende in the silver veins at depth apparently is not expressed as gamma-ray anomalies at the surface.

Introduction

Front Range, Colorado: The majority of the rocks comprising the Front Range of Colorado are pre-Cambrian schists, gneisses, and intrusives which have been elevated to form part of the Southern Rocky Mountain physiographic province. The region is noted mainly for its production of gold and silver, but ores of tungsten, fluorspar, uranium, copper, and iron have been worked. Geological literature[1-4] describes pitchblende and other radioactive minerals occurring at Jamestown, Boulder County; Central City, Gilpin County; and Lawson, Clear Creek County (fig. 1). These three adjoining counties cover most of the highly mineralized section of the Front Range which extends from Jamestown to Breckenridge. As far as the writer is aware, uranium has been found only in the portion northeast of Lawson.

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TP 2738 IL. Discussion of this paper (2 copies) may be sent to Transactions AIME before Feb. 28, 1950. Manuscript received March 30, 1949.

Silver Deposits at Caribou Hill: The historic silver deposits of Caribou Hill, located approximately half way between Jamestown and Central City, and 35 miles in a straight line northwest of Denver, appeared particularly intriguing as an area to prospect for uranium for the following reasons: here exists an isolated group of high-grade silver veins in the center of a mining district containing occurrences of uranium, and, in two of the well-known uranium deposits of the world, those at Great Bear Lake, Canada, and Joachimsthal, Czechoslovakia, uranium is associated with silver in similar fissure veins. An exploration program, conducted in the spring of 1945, directed special attention to Caribou Hill and was rewarded with the discovery of heavy, canary-yellow stained specimens of pitchblende.

The veins are confined to shear zones cutting a north-south, elongated quartz-monzonite stock of Tertiary (?) age lying in the axis of a major anticline of the Idaho Springs biotite schist, the oldest pre-Cambrian formation in the district. The stock is one and three-quarter miles long by more than a mile wide, and Caribou Hill is approximately at its center.

The ore zones vary in width from a few inches to 15 ft, and one structure has been traced for a length of over 4000 ft. The ore minerals are galena, sphalerite, ruby silver, native silver, chalcopyrite, pyrite, and pitchblende. They occur most common-

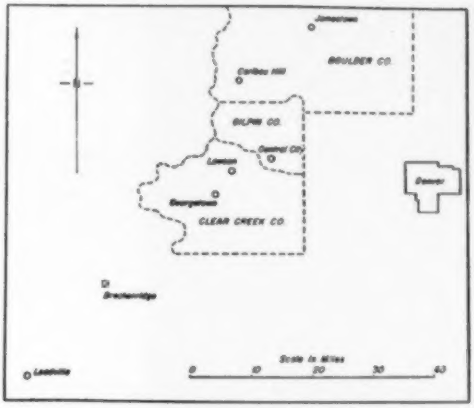

Fig. 1—Index map showing position of some of the major mining districts of the Front Range relative to Denver, Colo.

ly, finely and inconspicuously disseminated in vein matter or in the adjacent altered monzonite. Gangue minerals are mostly quartz, various colored carbonates, barite, some fluorite, and clay minerals that are the alteration products of feldspar and biotite of the wall rock.

An investigation of the mining properties of Caribou Hill resulted in the consolidation of the old Caribou mine property and other, adjacent properties believed to be important. In 1947, the Consolidated Caribou Silver Mines, Inc., began the rehabilitation of the old mine workings.

Geiger-Müller Survey

The surface of Caribou Hill and particularly the outcrops of the major ore-bearing structures were traversed with a Geiger-Müller counter sensitive to gamma radiation. As the Caribou mine was unwatered, the accessible levels and stopes were thoroughly traversed with the instrument. At intervals of from 50 to 100 ft, or wherever radioactivity was suspected, Geiger-Müller counts were recorded. The counts were taken for periods of from one to ten minutes and expressed as the average number of impulses per minute.

Explanation: Experience has shown that the count for the instrument used may fluctuate from ½ to 1½ times the average rate and still be in no way influenced by any near concentration of radioactive material. Hence, any count between 10 and 29 per minute was considered in the normal (N) range; from 30 to 47, in the twice normal or $2N$ range; from 48 to 66, in the $3N$ range, and so on. If an average count of below 10 was obtained, it was considered below normal and designated $N/2$. Experience has further shown that, if a radioactive element is present in sufficient quantity to be seen in its mineral form, or to be detected by ordinary chemical analysis, the count, at the place of exposure, is likely to be $5N$ or higher.

Normal (or Negative) Activity: The surface (except part of the Caribou dump) and most of the levels registered no above-normal radioactivity.

Below-normal Activity: On the 300 level a reading of 8 was obtained on one of the veins but, at this time, no particular significance is attached to this phenomenon.

Above-normal Activity: Four levels produced counts registering above-normal radioactivity, and the profiles of the gamma-ray intensities of these levels are illustrated in fig. 2. A single count at an isolated place on the 360 level ran 34, or 5 above the limit of the normal range. A group of counts taken on the 530 level ran 27, 18, 39, 24, 22, 38, 28, 36, 25, and 25 over a length of 220 ft. This is undoubtedly an anomaly, but too mild to indicate a concentration

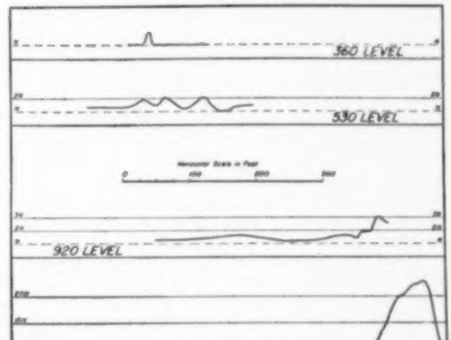

Fig. 2—Profiles of the gamma-ray intensities on the 360, 530, 920 and 1040 levels of the Caribou Mine.

The horizontal scale is in feet and is shown on the diagram. The vertical scales are the gamma-ray intensities expressed in the number of counts over the normal, background count of the country rock. The broken line marked N represents normal intensity.

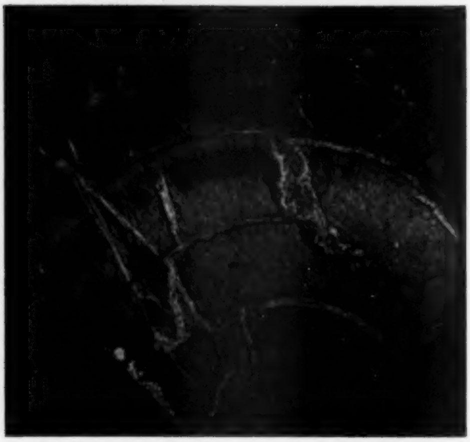

Fig. 3 — Low magnification micrograph of soft, black, colloform radioactive substance from the 1040 level of the Caribou mine. X17.

The light gray veins are proustite and sphalerite, each containing blebs of chalcopyrite.

of radioactive material that could be seen or detected by ordinary chemical analysis. The average count on the 920 level is noticeably higher than on any of the upper levels, and at the northeast end of the drift it begins to climb abruptly to 3*N*. The 1040 level is normal in gamma-ray activity except for the northeast 350 ft. The intensity of this anomaly is sufficient to indicate that a radioactive mineral is exposed along approximately 100 ft of this drift.

Description of Occurrence

Ore Body of the 1040 Level: At the northeast end of the 1040 level, channel samples, taken at 10 ft intervals, reveal an ore body 350 ft long with an average width of 4.08 ft and an average grade of 0.061 oz per ton gold, 18.96 oz per ton silver and 1.76 pct lead. It follows a northeast trending structure for 220 ft, then turns off to the east along a subsidiary east-west fracture for the remaining 130 ft. The ore varies from one to nine feet in width and is a siliceous- and carbonaceous-vein filling containing, in places, galena, sphalerite, and a little pyrite. In the east-west section, pitchblende and ruby silver are also visible. The pitchblende occurs in a continuous, black seam 1 to 16 in. wide which begins 45 ft southwest of the junction of the northeast and subsidiary structures and follows the footwall of the ore to the junction, then the center of the east-west striking vein for an additional 110 ft. This black material is radioactive and intensely so at places. It is friable and has an earthy luster and readily stains the fingers when handled. Veinlets of an easily shattered, black, vitreous, colloform pitchblende form part of the dark streak, and galena, sphalerite, ruby silver, and colloform pyrite also may be identified by hand lense.

Radioactive Ore under Low Power Magnification: A microscopic view of a polished section of the black material, viewed in reflected light under low power magnification, shows pitchblende and coarsely crystallized galena, sphalerite, and proustite. Chalcopyrite is present as small exsolution blebs in sphalerite and proustite and also in places

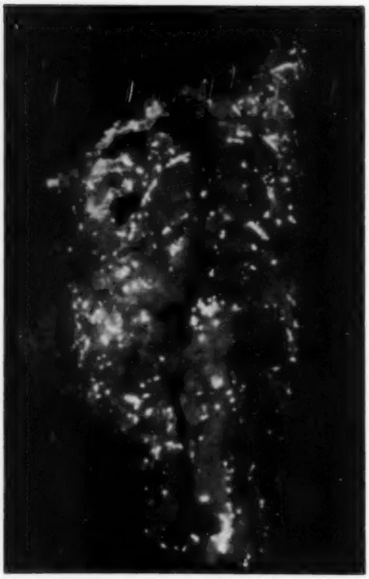

Fig. 4—Radiograph of polished section, part of which is shown in fig. 3 and fig. 5. X4.

The white areas are strongly radioactive, relatively pure pitchblende blebs. The dark gray area is the moderately radioactive, colloform substance. The black areas of the specimen are areas where radioactivity is negative.

independent of these minerals. Most of the section, however, is composed of a conspicuous, impure, gray colloform substance (fig. 3) resembling pitchblende in microscopic appearance, but too soft to be pitchblende. It has a sort of ground mass relationship to the more coarsely crystallized minerals. A radiograph of this section (fig. 4) shows it to be less radioactive than pure pitchblende, but does show that it contains, in places, blebs of a strongly

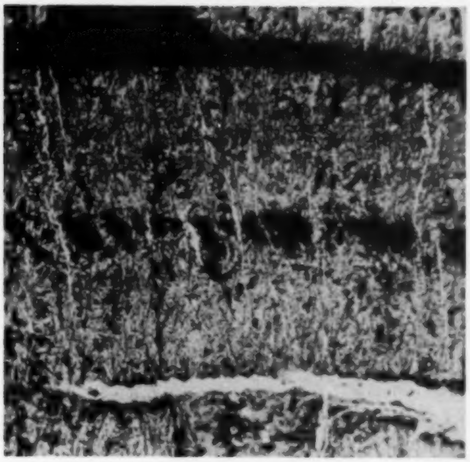

Fig. 5 — High magnification micrograph of the colloform substance shown in fig. 3. Oil emersion. X170.

radioactive mineral which has the physical, chemical, and radioactive properties of pitchblende.

Radioactive Ore under High Power Magnification: High power magnification of the colloform mixture (fig. 5) reveals an intimate mixture of a silver-white mineral and a dark gray mineral. The latter is believed to be pitchblende because of its color, habit, and reaction to reagents. The white-colored mineral is deeply etched by potassium cyanide and, when so etched and examined under high power magnification, it exhibits a deep red internal reflecion. Hence, this second component is apparently a ruby silver and probably proustite which is present elsewhere in the polished section.

Conclusions

The study of the radioactivity on the surface and within the Caribou mine brings to light three observations of possible interest to those using the Geiger-Müller counter in the search for pitchblende-bearing veins.

1. The surface survey failed to detect any evidence of above normal gamma-ray intensity over the country rock or along the outcrops of the veins, and, if the Caribou mine workings had not reached a depth of 1040 ft and pitchblende discovered on the Caribou dump, the pitchblende occurrence may never have been detected.

2. On the 1040 level, as the Geiger-Müller counter was moved along the drift toward the radioactive ore body, it first registered the anomaly at a distance of approximately 160 ft from the point where the nearest channel sample returned a value for uranium (fig. 2, 1040 level profile). The writer does not believe that the intensity at this location is due to radiation penetrating the full 160 ft; it is more likely due to the result of local radiation emanating from trace amounts of a radioactive element, or elements, in the vein within 5 ft or less of the instrument.

3. Both on the surface and underground, the quartz-monzonite host rock was found to possess a normal gamma-ray count. This observation is in direct contradiction to results obtained from similar studies[5] made by the writer in the Great Bear Lake Area, N.W.T., Canada, where the host rocks of the silver-pitchblende veins were found to be approximately one and one-half times as radioactive as the adjacent, nonhost formations. Hence, the prospector in search of radioactive deposits may reason that, from the results obtained at Caribou Hill, he need not confine his attention to formations possessing higher-than-average gamma radiation.

Acknowledgment

The writer is extremely grateful to Mr. Boris Pregel, President of Consolidated Caribou Silver Mines, Inc., for making possible the original program of exploration of the Front Range uranium areas in 1945, the subsequent geological and geophysical studies of the Caribou mine, and, finally, the preparation and reading of this paper. The writer is also grateful to Mr. Elmer Hetzer, Mine Superintendent, for his cooperation and assistance with the field work.

The polished sections, micrographs, radiograph, and microscopic studies were made in the geological laboratories of Princeton University. The writer wishes to thank Professor Edward Sampson and the Department of Geology for the use of its laboratory facilities in the preparation of this report.

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Cyclone Thickener

Applications in the Coal Industry

by M. G. Driessen and H. E. Criner

Possible applications of cyclone thickeners for: (1) clarification of the washery water and, (2) recovery of fine coal from the plant bleed. The paper shows: (1) that it is possible to remove all particles including the very finest, from the circulating water, thus obtaining a closed water system and, (2) that reduction of the ash content of the solids of the plant bleed is feasible by means of cyclone thickeners. Performance data for different size cyclones is given in the form of graphs.

THE cyclone thickener has two important applications in wet washing plants: (1) water clarification, and (2) fine coal recovery.

The thickener consists of a conical chamber into which the fluid is injected through a tangential nozzle at the periphery of the large end. The solids of the slurry are concentrated and removed from the apex of the cone while the "thinner" portion is discharged from a central tube in a flat head at the large end, fig. 1. The advantages of the cyclone thickener are that large volumes of slurry may be treated with small space requirements and that the underflow concentration may be controlled easily and readily to meet varying feed conditions.

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Control of Washery Water Solids Concentration: The first requirement, in the process of controlling solids concentration, is that the solids be removed from the body of circulating water at the rate at which they are introduced. If this condition is satisfied the concentration will remain at a fixed value and will not increase to uncontrollable levels. The second requirement is that the solids concentration

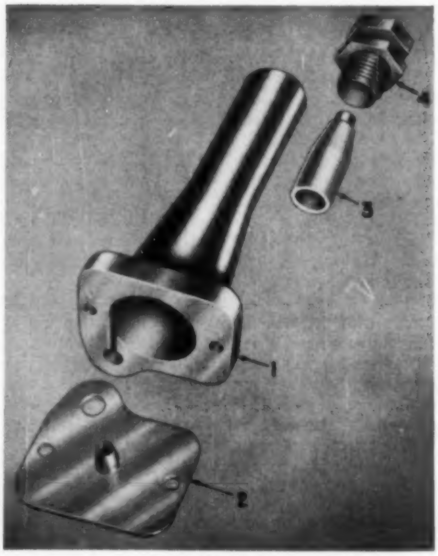


Fig. 1—A 3 in. rubber cyclone thickener.

1—Rubber cyclone body. 2—Cover with overflow opening. 3—Soft rubber orifice. 4—Nozzle retainer.

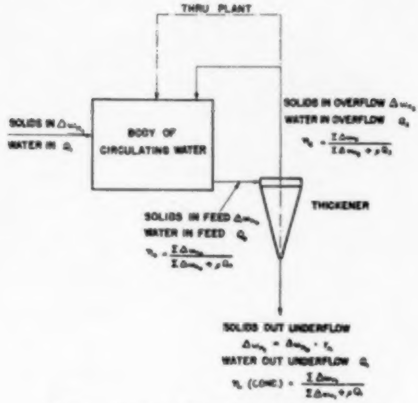


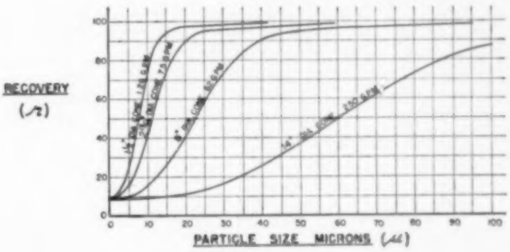
Fig. 2—System to separate solids from circulating water.

and to know the recovery characteristics of the thickener.

Suspended solids are introduced to the circulating water through the plant feed and through degradation of the feed within the plant. They are lost to the circulating water through removal with the coal and refuse. (The determination of the rate of loss may be complicated by final clear water flushing or drying with subsequent fines recovery by wet scrubbers.) The difference between the incoming and lost solids must be removed by the thickener if a closed circulating water system is being used. We will designate the amount of this difference by "the required removal rate."

The problem of solids control may be formulated in the following manner. Given the required removal rate in each solid size range, the thickener feed flow and recovery efficiency in each size range; find the stabilized thickener feed concentration and size distribution and the corresponding quantities for the overflow. The plant circulating water will usually consist of thickener overflow so that the result of the study specifies the concentration and

Fig. 3—Relative recovery efficiencies of various sizes of cyclone thickeners.



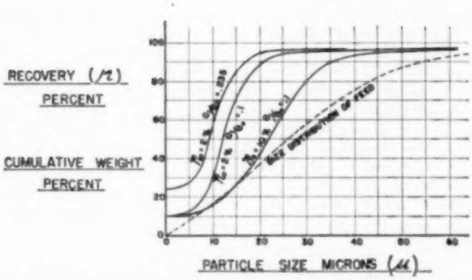


Fig. 4—Influence of feed concentration and flow ratio on recovery of 2 13/16 in. diam cyclone thickener.

be maintained at a usually low level for good washery performance.

To properly apply the cyclone thickener it is necessary to understand the general problem of solids control, to know the amounts and size consist of the solids to be removed from the circulating water, characteristics of the circulating water. Fig. 2 will help in the understanding of the problem.

Let $\Delta\omega_{n1}$ be the required solids removal rate for size range n. Let r_n be the thickener recovery value for this size range and $\Delta\omega_{n0}$ be the amount in the feed. Then $\Delta\omega_{n0} = \frac{\Delta\omega_{n1}}{r_n}$ or when the system is in balance it is necessary to circulate $\Delta\omega_{n0}$ pounds of solids through the thickener to remove the amount of solids ($\Delta\omega_{n1}$) coming into the circulating water. The indices 0, 1, and 2 refer, respectively, to feed, underflow, and overflow of the thickener.

As an example; it is required to remove 10,000 lb per hr of 375 to 230 mesh solids from the circulating water and the thickener recovery for this size range is 0.5 then it is necessary to feed 20,000 lb per hr of 375 to 230 mesh solids to the thickener.

The separate sums of the $\Delta\omega_{n1}$, $\Delta\omega_{n0}$ and $\Delta\omega_{n2}$ weights will give the entire weight rates contained in the underflow, feed and overflows respectively. The difference $\Delta\omega_{n0} - \Delta\omega_{n1}$ will give the separate size range weights in the overflow. Let η_0, η_1 and η_2 be the overall concentration in the feed, underflow

and overflow respectively, and Q_0, Q_1 and Q_2 be the flow at the corresponding points; then

$$\eta_0 = \frac{\Sigma\Delta\omega_{n0}}{\Sigma\Delta\omega_{n0} + \rho Q_0},\quad \eta_1 = \frac{\Sigma\Delta\omega_{n1}}{\Sigma\Delta\omega_{n1} + \rho Q_1} \text{ and}$$

$$\eta_2 = \frac{\Sigma\Delta\omega_{n2}}{\Sigma\Delta\omega_{n2} + \rho Q_2}$$

ρ being the density of water, 8.33 lb per gal.

Sometimes it is difficult to understand how a balance between the amount of solids coming into the system and the amount being removed through the underflow is achieved. Perhaps the following example will clarify this point. The amount of solids fed to the thickener will be almost proportional to the feed-solids concentration at a given total feed flow. Suppose we are removing 10,000 lb per hr through the underflow at 5 pct feed concentration, but there is only 5000 lb per hr coming into the circulating water. Since there is more material going out than coming in the concentration must be decreasing. As the concentration decreases less solid material enters the thickener feed and consequently the amount recovered through the underflow decreases. This gradual adjustment goes on until only 5000 lb per hr is going out through the underflow with a feed concentration of 2½ pct.

The second phase of the application problem is the determination of the required solids-removal rate. This may be most conveniently accomplished by analyzing the plant bleed. Suppose the feed rate to the plant, the volume of circulating water, and the bleed rate have all been maintained at constant values for several hours until no change is discernible in the bleed concentration. At that time a sample of the bleed water is secured, the bleed volume measured, and the average surface moisture content of the leaving coal and refuse secured. The bleed water sample is analyzed for concentration and solids size distribution. The volume leaving with the coal and refuse is added to the bleed to

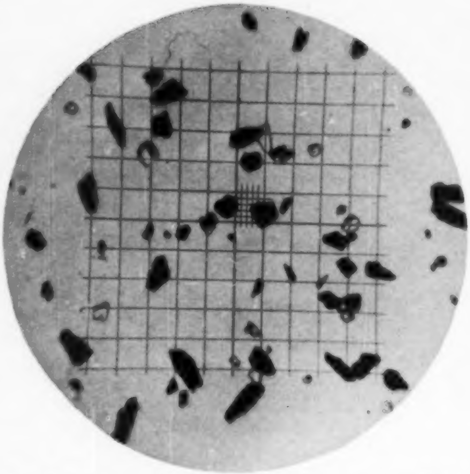


Fig. 5—Micrograph of 10 to 15 micron coal particles.

Small grid square 5.1 micron. Size analysis based on free settling rate of 1.35 sp gr spherical particle.

Table I—Calculation for Solids Concentration in Thickener Overflow Water

Measured Bleed Volume, 1,282 gpm
Total Bleed Weight, 663,700 lb per hr
Water Bleed Weight, 597,000 lb per hr
Solids Bleed Weight, 66,400 lb per hr
Total Volume of Sample, 1.0750 gal
Water Volume in Sample, 1.0000 gal
Total Weight of Solids in Sample, 0.9252 lb
Specific gravity of Sample, 1.034
Total Solids in Sample, 10 pct

Total Weight of Plant Coal and Refuse, 1,400,000 lb per hr
Average Leaving Moisture, Coal and Refuse, 7.25 pct
Weight of Lost Water, 101,300 lb per hr
Weight of Lost Solids with Coal and Refuse, 11,256 lb per hr
Total Weight of Solids Lost with Coal, Refuse and Bleed, 76,600 lb per hr

Size Groups (Microns)	(1) Solids Weight in Bleed Sample (Lb per Hr)	(2) Weight Solids out with Coal Refuse and Bleed (Lb per Hr)	(3) Weight Solids out with Coal and Refuse When Rinsed with Thickener Overflow at 3 Pct (Lb per Hr)	(4) (2)−(3) $\Delta\omega_{n1}$ (Lb per Hr)	(5) r	(6) $\Delta\omega_{n0}$ (Lb per Hr)	(7) $\Delta\omega_{n2}$ (Lb per Hr)
0–10	0.0387	3,243	1,323	1,920	0.12	16,000	14,080
10–20	0.0456	3,825	745	3,080	0.28	11,000	7,920
20–30	0.0761	6,376	376	6,000	0.60	10,000	4,000
30–44	0.0926	7,721	127	7,650	0.85	9,000	1,350
44–62	0.102	8,558	52	8,450	0.94	9,000	550
62–125	0.1392	11,683	33	11,650	0.97	12,000	350
>125	0.433	36,250	0	36,250	1.00	36,250	0
	0.9252	77,656	2,656	75,000		103,250	31,250

For underflow concentration of 40 pct at flow ratio of 0.1 $Q_1 = 224.5$ gpm or 112,500 lb water per hr.
$Q_0 = 2245$ gpm $\eta_0 = 8.4$ pct.
$Q_2 = 2020.5$ gpm $\eta_2 = 3.0$ pct.

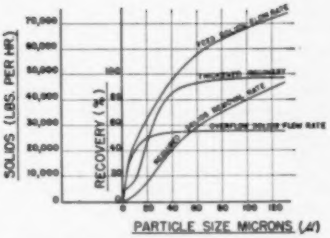


Fig. 6—Amounts and size distribution of solids in feed, overflow and underflow of cyclone thickener application to circulating water solids control.

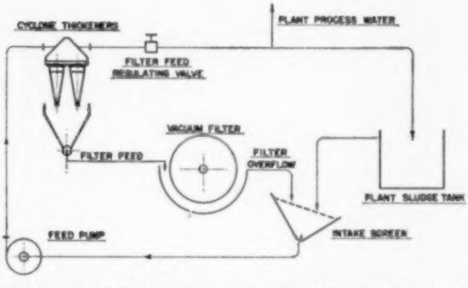


Fig. 7—Schematic diagram for washery water clarification system.

give an overall rate of slurry removal. Call this rate Q and the sample volume of bleed V. From the bleed sample volume it has been found that in volume V there is a weight in size range n of ΔE_n pounds of solids. Then $\Delta\omega_{n1} = \frac{Q}{V}\Delta E_n$. Assume for the moment that the thickener overflow concentration and size distribution has been calculated as a first approximation from the above ω_n's. If this fluid is used as the last flushing water for the leaving coal and refuse then the residual moisture on this material will carry some solids in the entrained water. Let the weight of these solids be $\Delta\omega_n^1 = m\,\omega_c\,\Delta\omega_{n1}/\rho Q_2$ where m is the plant discharge average moisture percentage, ω_c the weight of coal and refuse, and the other factors as previously defined. Then as a second and closer approximation, the required removal rate for the thickener is only $(\Delta\omega_{n1} - \Delta\omega_n^1)$.

The third requirement in the analysis of the problem is the thickener characteristics. The factors influencing the thickener recovery values are: (1) size and proportions of the unit, (2) the feed concentration, (3) the flow ratio, and (4) the size consist of the solids.

The term flow ratio is defined as the fraction of the feed-water volume that leaves by the underflow orifice. If Q_0 is the feed water amount and Q_1 the rate of water flow from the underflow, then Q_1/Q_0 is the water-flow ratio.

The effect of unit size on the recovery efficiency is shown by fig. 3. The size of the thickener most adaptable to the problem is chosen by considering the size consist of the solids which must be removed. In general if there are large percentages of very fine solids present a small diameter unit must be chosen for the job.

Fig. 4 shows the effect of flow ratio and feed concentration, at one size consist on the recovery values. Curves for the full range variation of these parameters are too voluminous to include in this paper, but these will serve to indicate the trends. The lower solids recovery curves show the effect of changing feed concentration from 2 to 10 pct while maintaining the flow ratio, Q_1/Q_0, at 0.1. The effect of flow ratio on the recovery is shown by comparing the 2 pct feed curves at $Q_1/Q_0 = 0.1$ with that for $Q_1/Q_0 = 0.235$. We have been speaking of particle size and our curves are shown with particle dimensions in microns (μ). A micron is meant to be a length of 0.0001 cm. We are talking about an equivalent particle as determined by settling rate rather than an actual physical dimension. The actual particle is one whose settling rate is the same as that for the specified diameter, of 1.35 sp gr, settling in water, spherical in shape, and not influenced by solids volumetric concentration.

To secure the characteristic curves discussed above it was necessary to develop an extremely accurate means of isolating the size groups in the samples of feed, overflow, and underflow from the various thickener test runs. Our laboratory uses the decantation method with certain techniques to give the required accuracy. The "purity" of the size group separated by such an analysis may be seen by examining the micrograph, fig. 5.

The method used is one of elutriation by decantation. The sample is at first dispersed in a medium of methyl alcohol and carbon tetrachloride (sp gr, 1.00), and allowed to settle a known distance. As particles of very small terminal velocities should be removed, decantation takes place in a centrifuge. Those particles which are not settled in a certain time, and thus have terminal velocities smaller than a certain calculated velocity (Stokes law), are removed. The rest is diluted with the above mentioned liquid and the process of removing small particles of a certain size range is repeated. For coal particles of a size range 0 to 2.5 microns the process of diluting and decantation has to be repeated up to 50 times.

Although a little elaborate, it is the only method which yields reproducible results, and where the different size ranges are isolated in order to determine further data, such as ash and sulphur content.

An example of the calculation principle discussed above is shown in Table I. Appendix *A* gives a discussion of the calculation sequence. The results represent several trials gradually yielding the correct size distribution in the feed and overflow. It has been calculated on the assumption that the leaving coal and refuse was rinsed with the overflow water. The curves of fig. 6 summarize the results and give an idea of the size consist of the circulating water after the system has been balanced.

Prospective users of the cyclone thickener are frequently puzzled as to why the fine solids do not continuously "build up" in the circulating water

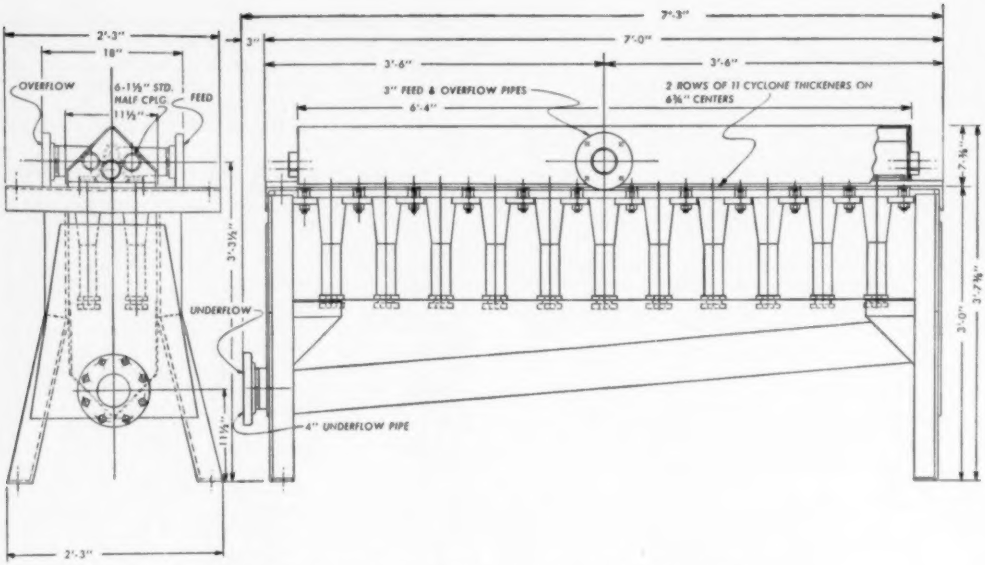


Fig. 8—Arrangement for a 200 gpm cyclone thickener manifold.

because they are being returned through the overflow to the circulating water. The answer to this is that not all of even the very smallest particles are being returned. A fraction is being continuously removed from the underflow along with the concentrated body of larger particles. As long as the recovery value (r) does not approach zero this will be true. As long as there is any fluid contained with the underflow solids r cannot be zero, since the very finest particles tend to make themselves a "part of the fluid." The experimental evidence verifying this viewpoint, is shown on the recovery curves of fig. 4. Particle size groups down to 2½ microns have been isolated in producing the curves, and all data shows that r approaches the value of the flow ratio at the smallest particle diameters.

A practical example of such a water clarification system is shown in the flow diagram of fig. 7. This apparatus is being installed in a modern bituminous coal washery handling about 350 tph. The thickeners and filter must remove 17½ tph of suspended solids from the circulating water. About 32 pct of the material is less than 325 mesh. They must deliver the slurry to the filter at about 30 pct concentration and hold the circulating water to less than 8 pct solids. The thickener feed will be 1600 gpm at 40 psi inlet pressure. The power requirements will be about 3.3 hp per 100 gpm at 70 pct pump efficiency neglecting head and piping losses.

The installation consists of 8 manifold assemblies of standard design flowing 200 gpm each. Fig. 8 shows the manifold arrangement.

Fine Coal Recovery by Means of the Cyclone Thickener: The practice of discarding fine coal to a disposal basin or stream may in some cases result in a loss of 5 pct of the plant product. Efforts have been made to recover as much as possible by screening, but screens of ¾ and ½ mm size cannot recover a great deal more than can usually be settled in a reasonably sized drag conveyor sludge tank. This is sometimes a rather good coal and it may be beneficiated easily with a simple classifying process

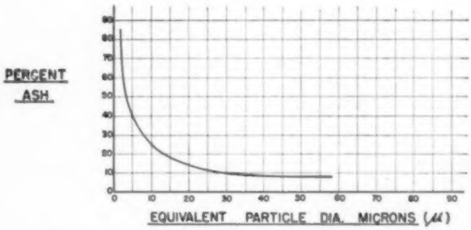


Fig. 9—Ash content - particle size curve for actual slurry sample.

Equivalent size based on 1.35 sp gr spherical particle.

because the high ash material is in the smaller size ranges. Fig. 9 is descriptive of this type of slurry solids.

The cyclone thickener is adaptable to this type of problem because it can classify large volumes of slurry in a small apparatus and produce a thickened clean underflow. Secondary benefits such as increased sludge pond life may be realized.

A larger unit is usually most adaptable to this

type of problem and the rate of flow through it may be changed to vary the classification point.

The elements of such a coal recovery scheme are simple. The thickener feed is removed from the plant sludge tank or from the underflows of dewatering screens or centrifugal driers and pumped to the thickeners. The underflow of the thickeners is usually fed to a filter for further dewatering and all or a portion of the overflow bled from the plant to a disposal basin. If only a fraction of the overflow is bled to waste then the thickener again becomes a part of the circulating water system and its effect on the system may be determined by the procedures discussed in the previous section. The only basic variation from the above discussion is in the modification of the effective thickener recovery values (r) by the overflow bleed.

The solids removed from the circulating water are now the sum of the underflow and those bled to waste through the overflow fraction. Let p be the fraction of overflow bled to waste, then $p\Delta\omega_{n2}$ is the fraction of overflow solids of size range n going to waste. $(p\Delta\omega_{n2} + \Delta\omega_{n1})$ is the total weight removed of size range n from the system. Since $\Delta\omega_{n2} = \Delta\omega_{n0} (1 - r_n)$ and $\Delta\omega_{n1} = r_n \Delta\omega_{n0}$ the above expression becomes $\Delta\omega_{n0} \{p (1 - r_n) + r_n\} = \Delta\omega_n$, where $\Delta\omega_n$ is as before the required removal rate of size range n and $\Delta\omega_{n1}$ was the portion of this removed through the thickener underflow. $\Delta\omega_n/\Delta\omega_{n0} = r_n^1$ or the new effective recovery value for the combination of thickener and thickener bleed so that $r_n^1 = p (1 - r_n) + r_n = r_n \{p (1/r_n - 1) + 1\}$. The new value, r_n^1, is calculated from the selected bleed fraction n and the recovery value for the thickener r_n, are used in the calculation procedure in the same manner as illustrated in Table I.

A proposed solids recovery system operating on the slurry of a midwestern plant had the following characteristics.

The total feed flow to the thickeners was 800 gpm and contained 21 tph of solids. The concentration was 10 pct and the ash content 15.7 pct.

The underflow was recovered at 52 pct concentration. The ash content was 8 pct and it contained 64 pct of the total solids so that the sludge pond life was increased by about 3 times.

The overflow concentration was 4 pct and the ash content of the contained solids was 30 pct.

From the above data it may be seen that appreciable amounts of useful coal can be recovered and beneficiated and at the same time increased settling pond life realized.

This discussion is primarily intended to acquaint operators with the characteristics and possibilities of the cyclone thickener. With such knowledge it is possible to think of other applications unique to the individual washery. It is hoped that the paper will accomplish this result.

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Appendix A

Discussion of the Calculation Sequence for Table I: The sample was analyzed yielding the size fraction weights in col. 1. The total weight of solids and water in the sample was 9.255 lb and the volume 1.075 gal so that the specific gravity was 1.034. The measured bleed volume was 1282 gpm so that the total weight of bleed slurry was 1.034 x 8.33 x 1282 x 60 = 663,700 lb per hr. There were 10 pct solids by weight in the sample so the bleed must have contained 66,400 lb per hr of solids. The plant was running 700 tph with an average leaving moisture of 7.25 pct so that the water loss from this source was 101,300 lb per hr again containing 10 pct solid so that the total suspended solids removal rate was 66,400 + 11,256 = 77,656 lb per hr. These solids were distributed between the various size groups in the same proportion as found in the sample. As an example there were 0.0387 lb of 0-10μ material in the sample so that $\frac{77,656}{0.9252} \times 0.0387 =$ 3242 lb per hr of 0-10μ was being removed by coal, refuse and bleed.

We must now establish a tentative figure for the amounts of solids lost with coal and refuse after the thickeners are installed. We know that the solids loss will be somewhat less than a proportional figure for the concentration reduction from 10 to the estimated 3 pct. This will be about 2500 lb per hr instead of the former 11,256 lb per hr. Because of previous experience with this type of problem we will have a fair idea of the distribution of the 2656 lb between the various size groups. We will subtract these tentative figures from the weights in col. 2 and secure an estimation of the amounts removed through the thickener underflow, col. 4.

Using a trial flow ratio of 0.1 and an estimated feed concentration of 10 pct we will copy the recovery figures of col. 5 from the proper recovery curve. The process of dividing the amounts in col. 4 by the recoveries will yield the feed weights of col. 6. Subtracting col. 4 from col. 6 will give the weights of solids in the overflow in each size range.

If it is desired to maintain a 40 pct underflow concentration a total slurry weight of $\frac{75,000}{0.4} =$ 187,500 lb per hr must flow from the thickener underflows. The weight of water contained herein is the difference 187,500 — 75,000 = 112,500 lb per hr. For the flow ratio of 0.1, 1,125,000 lb of feed water must be circulated each hour. The total feed solids is the sum of col. 6, and this, combined with the feed water, gives a feed concentration of 8.4 pct.

There are other calculation methods that will eliminate the above trial procedure, but a discussion is too involved to present here. The example should serve to illustrate the principles.

Chromite and Other Mineral Occurrences

in the Taştepe District of Eskişehir, Turkey

This paper is the first in a series which will describe geology, mining methods, and production costs of some of Turkey's more important minerals. In this paper the economically significant minerals—chromite, meerschaum, and magnesite—of the Taştepe district are described. The cost data presented are believed by the author to be the first made public on Turkish chromite mining.

by Ferid Kromer

Geography: The Taştepe district of the Vilayet of Eskişehir is about 20 miles northeast of the city of Eskişehir (approximately midway between Ankara and Istanbul) in western Anatolia. The area is a mountainous one, the highest peak being Taştepe Mountain (5200 ft) which is approximately in the center of the district. The mountains drop off to the deep valley of the Sakarya River on the north and to the plain of Eskişehir on the south.

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For the most part, the watershed is on the northern side of the mountain barrier, draining into the Sakarya River, which in turn empties into the Black Sea midway between Zonguldak and the mouth of the Bosphorus. The approximate area covered by the Taştepe district is shown in fig. 1.

Transportation to shipping points is available via the Istanbul-Ankara railroad. The station on this line nearest the mining district is Alpiköy station, about 20 miles by road southwest of Taştepe Mountain. Interior roads within the district are poor. Being of dirt, the winter rains and snows render them almost impassable for trucks from about the middle of December until the end of March, thus presenting a considerable transportation problem. However, the roads from the Başören and Taştepe chromite mines to the railroad shipping point at Alpiköy station have recently been repaired and will be maintained for all-weather truck transportation.

Detailed climatic data are not available. However, in general the spring, summer, and early autumn months are dry, and good weather may be expected from May until early November. Then the winter rains commence, and heavy snow is usual during January and February.

Geology: The mountainous structure of Taştepe belongs to basic rocks of serpentine (Variscan Orogeny) which is in contact with Paleozoic schists at west, and an Oligocene outcrop of red clays in Margi-Sepetçi region (see fig. 1) at southeast.

The northwest and southwest borders of Taştepe district are, respectively, surrounded by Paleozoic schists and pebbly gray and yellow Neogene clays. More recent formations of alluviums overlay the plain of Eskişehir.

Dark basic rocks of trachytes with hornblende are visible on Türkmenbaba Mountain, at the west of Taştepe.

Mineral Occurrences: *Chromite:* the most important mineral found in any quantity in the Taştepe district. The alignment of the deposits of chromite is in general along the line Başören-Taştepe (see fig. 1). The first mines in the area were those of Taştepe and Başören, which were developed over 20 years ago with Swedish capital. Other deposits of chromite, more recently discovered and so far of less importance, are being worked at Kuruçör, Kömürcü, Gelinmezari, and Laçin (see fig. 1). Deposits average generally between 46 and 48 pct chromic oxide, with the exception of the Başören mine which averages 44 pct. However, a new lode, very recently plotted, in the Taştepe mine averages 50 pct Cr_2O_3, 4.6 pct SiO_2, and 7 pct FeO.

Geological character of the chromite occurrences in the Taştepe mine may be considered typical of most chromite lodes in this area. The indications are that the formations of ore lenses are developed by the segregation of chromite crystals intruded into the serpentinized rock, and exposed later to tectonic movement within the zone of crystallization. All lenticular masses are more or less regular in shape and follow each other in southeast-northwest direction and dip generally 70° NE. Ore lenses do not seem to persist in depth, average depth of two lenses is 60 ft below surface. Three lodes have been mined as open-pit. The average dimensions of individual lenses are as follows: pitch length, 100 ft; breadth, 27 ft; and width, 20 ft.

The lenses and their enclosing rocks are broken by parallel fractures in approximately east-west direction. These joints are filled, except in one lode, with cementing material, which gives to the ore a

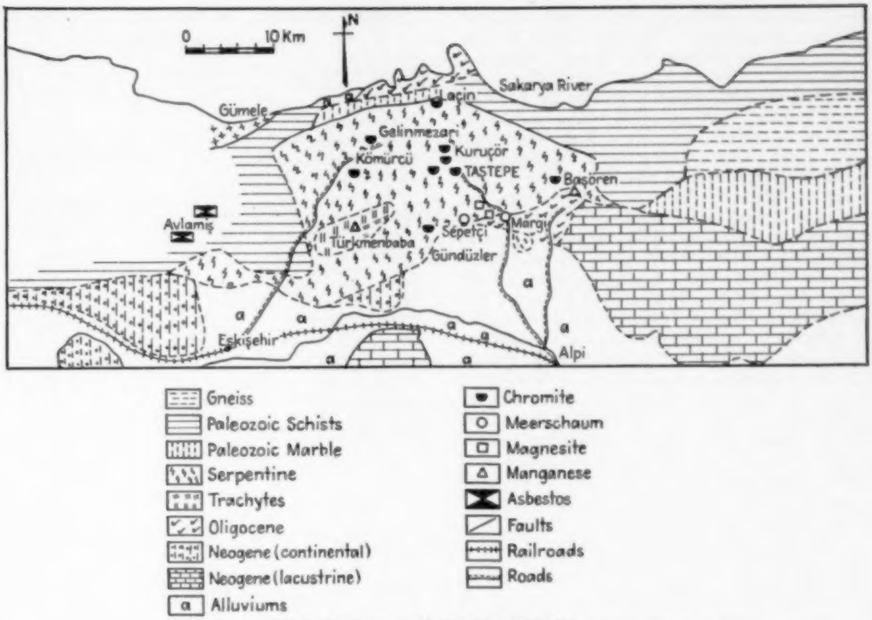

Fig. 1—Geological map of Taştepe District. *(After Stchepinsky.)*

more compact structure, thus permitting it to be mined with smaller pillars, larger openings, and higher efficiency in blasting. Some of the lodes are faulted. While the grade is maintained up to the faulted plane, it gradually fades out toward the peripheries in the direction of fracture planes. The fading out is sometimes accompanied by visible mineralogical changes in the cementing serpentine of ore.

The lenticular bodies which are oriented with their planes of greatest dimensions roughly in a northwest direction follow one another in that same direction. They do not seem to be connected with each other. However, the territory which falls within that direction, and the sublevels of the present workings need to be explored for determining the depth and extensions of the ore lodes.

Explorations conducted in 1948 have led to the discovery of 12,000 tons (metric) of visible chromite in Taştepe mine, and further investigations will be conducted in the same direction by next year.

At the Başören mine, farther to the east, the lodes are of a more sprinkled and spotted type of formation. The deposits extend in a southeast-northwest direction and reach a depth of about 150 ft below the surface. Present estimates indicate chromite reserves of about 25,000 tons in the Başören mine with an average grade of 44 pct of chromic oxide. Other deposits have recently been developed northwest of the Taştepe mine. No definite information is at present available indicating the ultimate reserves in this area. However, our estimate based on limited exploration made during the past summer indicates reserves as follows: Kömürcü, 2000 tons; Gelinmezari, 5000 tons; and Laçin, 5000 tons.

Meerschaum: second to chromite in importance in this area. Meerschaum occurs as nodular lumps of varying sizes principally between Margi and Sepetçi (see fig. 1). It is found buried in a sandy seam of clay running in a southeasterly direction. The seam varies in depth from 20 to 150 ft below the surface, and is covered by an overburden of red Oligocene clays. The seam carrying meerschaum nodules is characteristically faulted; the throw along the fault varies between 10 and 30 ft with a maximum dip of 70° SE. No idea can be formulated at present about the extent of the meerschaum reserves. The area containing meerschaum appears to extend as far as 15 miles NW of Sepetçi, in the direction of Eskişehir.

Magnesite: of frequent occurrence on the eastern slopes of the Taştepe range, particularly between Margi and Taştepe Mountain. It is formed in veins associated with serpentine. The thickness of the beds varies between 6 and 15 ft. An analysis of a recent 2000 ton shipment from this area gave the following results: MgO, CO_2, 95.5 pct; CaO, 1.5 pct; Fe_2O_3, Al_2O_3, 0.6 pct; and SiO_2, 1.0 pct. Several outcrops are visible within the district. At the present writing, the most productive property has a reserve of 30,000 tons of good grade magnesite.

While other minerals such as manganese, iron, mineral water, and certain clays do occur in the Taştepe range, they have not yet been found in profitable exploitable quantities.

Mining Methods and Mining Costs: *Chromite:* All except Taştepe and Başören mines are worked as open-pit mines. However, most of workings in Laçin mine will be centralized in underground exploration and production by the end of this year. In Taştepe mine, for example, a vertical shaft for

individual lenses is sunk in a hanging wall, and the ore is reached by crosscuts. The drifts are 8 ft high by 8 ft wide and are untimbered. From bottom up, tops are robbed and stopes are filled with waste. Taştepe mine has a compressor, driven by a 25 hp Atlas diesel engine. Free air at 90 cfm is delivered at a pressure of 70 psi through a 3 in. pipe to a 3½ x 7 ft receiver in the compressor building, and from there through a 2½ in. pipe to the mine. The compressor building is about 600 yards from the mine. Drilling in the mine is done dry with Atlas jackhammers, ⅞ in. hollow hexagon steel rod with ⅞ x 3¼ in. shank and jackbits are used. Mining is done by three drillers and helpers per jackhammer working an 8 hr shift. Drilling and mucking are done by drillers. About thirteen 3 1/3 ft jackhammer holes are drilled per day, and eighteen sticks (25 mm, 75 g) of Polar blasting gelatin (82 pct nitroglycerin), are used in 13 holes, the rounds usually break 25 to 30 tons of material. Large boulders resulting from the blast are broken by sledging. The broken ore is loaded into an 800 lb hoisting bucket on a truck which is trammed to the shaft bottom over a track of 12 lb rails and 24 in. gauge. The bucket is hoisted up the shaft with a hoist driven by a 6 hp gasoline engine, and dumped into a 2½ ton side-dump car.

At Başören mine the underground water presents some difficulty, but the operations can be continued without interruption throughout the year. At all chromite mines, except Taştepe mine, drilling is done with hand drills. Their operations, however, are similar to those at the Taştepe mine.

Tables I and II show a breakdown of the actual production cost per ton of mining marketable chromite ore at the Taştepe mine. These are presented as representative figures for the operation of an efficiently managed, medium-size chromite mine in this area. At Başören mine cost per ton is somewhat higher than normal because of the presence of underground water and the inefficient use of man power. Open-pit mining costs are somewhat lower, however, the costs in the Taştepe region varying between 5 and 8 Turkish liras per ton of marketable chromite.

During the 1948 season the Taştepe mines will have sold approximately 12,000 tons of chromite, the bulk of which has gone to Austria.

Meerschaum: Meerschaum mining is done by sinking shafts vertically until the seam carrying the meerschaum is reached, and then drawing narrow galleries along the strike of the seam. The depth of workings is limited by underground water level. Mining is done by pick and shovel; ventilation is secured through the galleries connecting the shafts. The ground, which is of residual clays derived from serpentine, is solid, but it would necessitate timbering when large openings are driven. The present openings are narrow, 3 x 3 ft, and untimbered. Actually there is no centrally directed organization or exploitation of meerschaum mining in the Taştepe district. Peasants in villages near the mines work mostly during the winter season and are paid according to the quality and amount of meerschaum which they produce. Proper organization and mechanization of meerschaum mines might well constitute an interesting and profitable enterprise. Preliminary treatment of meerschaum consists of removing dirt, drying, and polishing. Price quotations are made according to standard-size cases. Polished meerschaum pieces are sorted into seven grades which are in turn classified into twelve groups. Shipment of the grades known as Lager, Grosse Baumwolle, and Kleine Baumwolle is made in standard 16.5 x 34 x 70 cm cases and of the grades known as Polierte Kasten, Geputzt, and Ciliz in standard cases 34 x 17 x 80 cm. The present price for Lager on the European market is 210.00 dollars per case. No figures are currently available on meerschaum mining costs.

Table I—Chromite Mining Costs at Taştepe Mine.
(1 Turkish lira = 36 cents)

Period Covered—June 8 to October 1, 1948

Sorted chromite ore	2,250 Tons
Sorted waste	750 Tons
Output hoisted	3,000 Tons

Underground Costs per Ton of Chromite Ore Sorted

	Labor	Supervision	Power	Explosives	Supplies	Total
Prospecting, exploration and development	0.53		0.20	0.22	0.44	1.39
Mining	1.10		0.60	1.00	0.80	3.50
Underground tramming	1.70					1.70
Hoisting	0.30				0.10	0.40
General underground expense	0.10	0.40				0.50
Surface exploration applicable to underground operation	0.40					0.40
Total underground expense	4.13	0.40	0.80	1.22	1.34	7.89
Surface sorting	0.60					0.60
Total direct mining	4.73	0.40	0.80	1.22	1.34	8.49

Table II—Direct Mine Labor

No. of Workers	Occupation	Average Rate, T.L.	Average Cost per Day
10	Drillers and Field Prospectors	3.20	32.00
13	Trammers	2.50	35.00
2	Hoistmen	3.00	6.00
7	Ore Sorters	1.69	11.83
4	Blacksmith, Motormen, Guardian	3.42	13.68
1	Superviser	4.00	4.00
37			100.92

Magnesite: Magnesite mining in the Taştepe district was recommenced this year after a long period of inactivity. Magnesite mines are worked as open-pit mining. The cost of mining magnesite is about 4 liras per ton, based on this year's production of 2000 ton. A furnace has been built with a capacity of 15 ton daily for calcined magnesite. This furnace will probably absorb the entire output of this district.

Conclusion

The Taştepe district offers a great opportunity for extensive mining of chromite, meerschaum, and magnesite ores of good grade. While available reserves are not at present fully known, a rational exploitation of these resources with emphasis on prospecting and exploration, together with a capital investment adequate to permit mining and development by modern methods, should insure a profitable return on the investment.

Comparative Furnace Designs for the Expansion of Perlite

by John B. Murdock and Herbert A. Stein

Perlite is a natural volcanic glass which expands into an insulation material upon the application of heat. This paper discusses the operating characteristics of eight different types of furnaces for the expansion of perlite. It also includes a section on the theory of perlite expansion which serves as the basis for the authors' analysis of the furnaces.

An analysis of perlite expansion furnaces must be based upon one consistent theory which explains how and why perlite does expand when heated. There is more than one such theory, so to establish a basis for the rest of this paper, the authors will outline one theory and the data that support it before going into the construction details of different furnaces.

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Why Perlite Expands: Perlite is known to contain some dissolved or combined fluid, probably water, which is lost when the material is heated to fusion. It is generally agreed that when particles of this volcanic glass are heated to fusion in such a way that vaporization of this water into steam takes place at the same time as the glass becomes soft, the steam puffs up each particle into a mass of glass foam. It is a simple matter to expand perlite under a blow torch for demonstration purposes, but in commercial installations, the problem is made more complicated by the necessity of making efficient use of both raw material and fuel, and producing an expanded aggregate conforming to close specifications for size distribution and density, using many different types of perlite rock. The ability of a given operation to fulfill these requirements depends upon the proper handling of four variables. They are: (1) the nature of the perlite rock used, (2) the heating time taken to get the perlite particle up to its highest temperature, (3) the size of the particle, and (4) the maximum temperature the particle reaches.

Types of Perlite Rock: Perlite may be classified in many ways, but the characteristics most easily correlated with its behavior in furnaces are its softening temperature, its effective water content, and its "liveliness." Actually there is a close correlation among these three characteristics so it is possible to describe a perlite using any one of them. Lively perlites always have low softening temperatures and high effective water contents, whereas the deader perlites have higher softening temperatures and lower effective water contents. These softening temperatures run from 1400°F to above 2000°F and the effective water contents run from over 2 pct down to 0.2 pct. Included in the category of lively glasses are the green pitchstone from the Edgar claim in Superior, Ariz., the red pitchstone on the Animas highway south of Lordsburg, N. Mex., and a gray glass from Beatty, Nevada. Examples of intermediate perlites (in order of decreasing liveliness) are the Guzman-Lobb perlite with obsidian

balls from Picket Post Mountain, Superior, Ariz. (formerly used by Rheem Research Products, Inc., Los Angeles), the Snow White perlite from the same area (used by the Great Lakes Carbon Corp., Torrance, Calif.), and the light gray granular perlite from Socorro, N. Mex. (also used by the Great Lakes Carbon Corp.). Deader perlites include the gray and black perlites of the Lady Frances mine, Deschutes River, Oregon (used by Dant and Russell, St. Helens, Oregon), and the green John-Clare perlite from near Texas Creek, Colo. (used by Alexander Film Co., Colorado Springs, Colo.). It should not be inferred that one of these perlites is "better" than another. Each rock is suited for use in a particular type of furnace, and in that furnace it makes a characteristic product.

The softening temperature, or expansion temperature, of a perlite may be determined by trial and error in electric muffle furnaces heated to different temperatures, or by optical pyrometer observations in continuous furnaces in which a bed of expanding material is accessible for viewing. Effective water content is tested by a "loss upon ignition test" where the sample is previously heated to some intermediate temperature around 700°F instead of to the conventional 220°F. Prospectors test the relative "liveliness" of different types of perlite rock by exposing half-inch pieces to the flame of a gasoline blow torch. Lively perlites expand easily and to a high degree, even when brought up to temperature slowly, whereas dead perlites subjected to the same treatment expand only slightly, often only at the edges, and sometimes not at all. Failure to expand under a blow torch is not an indication that a given type of perlite is unsuitable for expansion. There is one variety of dead gray glass which does not show even the slightest tendency to expand under a blow torch, yet when it is brought rapidly up to temperature in a properly adjusted furnace, it expands over twelve times. An acetylene torch is useful in determining whether an ore does actually expand if no expansion is obtained under a blow torch, as it allows much quicker heating to higher temperatures. Dead perlites must be subjected to higher temperatures than lively ones in order to obtain a given degree of expansion. This is due to the fact that a higher temperature provides the quick heating needed by dead perlites, as well as to the fact that the softening temperature of a dead glass is generally higher than that of a lively glass.

Heating Time: While many furnaces provide other than linear time-temperature curves, it is simpler and just as instructive to describe the time-temperature characteristics of a given operation in terms of two variables, the maximum temperature reached and the time taken to reach that temperature, which may be referred to as heating time. This heating time is usually not equal to retention time, which is the time the perlite remains in the furnace.

Early observers noted that if too long a time were taken to heat perlite up to its softening temperature, much of the dissolved water would seem to have escaped before the softening point was reached, and the final expansion of the glass would not be as great as when shorter heating times were used, even though the final temperatures reached were the same in each case. It was also noted that for each perlite there was a lower limit to which the heating time could be reduced. As the heating time was decreased, the expansion ratio increased until finally the particles started breaking up under the sudden expansion. For very short heating times, these fragments when collected would show a very low bulk density, indicating that there had been considerable expansion. However, control had been lost over the size distribution of the expanded material, and the particles of expanded perlite were even smaller in diameter than were the grains of crude rock. It was also noted that the strength of the

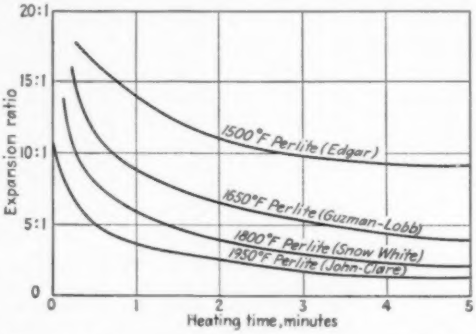


Fig. 1—Maximum possible expansion versus heating time for perlites which expand at various temperatures.

particles dropped quickly as the expansion ratio increased above a ratio of ten to one.

Impressed by the importance of heating time in determining the physical properties of the expanded product, the authors made a study of the exact relation between expansion ratio and heating time. Fig. 1 shows curves illustrating this relation for four perlites ranging from a lively glass which expands at a furnace temperature of 1550°F, to a dead glass which expands at 1950°F. These curves show that for heating times of several minutes, very small expansion ratios are usually encountered, whereas shorter heating times give more expansion. In the case of the Guzman-Lobb perlite, 40 sec was the longest permissible heating time to produce an expansion of ten to one, but with the green pitchstone from the Edgar claim, a ten to one expansion could be obtained *even with* a 4 min heating time. There were still other perlites such as the John-Clare perlite with which an expansion of ten to one could be reached *only with* a heating time of less than 5 sec. It should be noted that the perlites which require the shortest heating time to give good expansion are also the highest temperature perlites, whereas the perlites that can stand the longer heating time take a lower expansion temperature.*

* One known exception to this rule is a black obsidian which shows a very good expansion when raised to a temperature well over 2000°F with a heating time of several minutes.

Size Distribution of the Feed: Besides the heating time and the nature of the glass used, the size of the particles to be expanded is of importance. It takes more time for heat to be transferred into the interior of large particles, and large particles offer less sur-

face for heat transfer. Therefore, perlites which require short heating times for a given expansion cannot come in particles larger than a certain size. Using the same perlites mentioned above as examples, to give an expansion of ten to one the John-Clare perlite cannot be larger than 12 mesh, the Guzman-Lobb perlite cannot be larger than 6 mesh, whereas the Edgar perlite can come in half-inch pieces and still expand ten to one. This difference in permissible sizes is due to the comparison between the maximum heating time allowable for a given expansion of the particular glass and the minimum heating time necessary for heat to travel into the interior of the particles. The maximum size particle which can be expanded to a given degree for a given perlite is that particle which can just be brought up to its softening point in the same time which is the maximum allowable time for that degree of expansion.

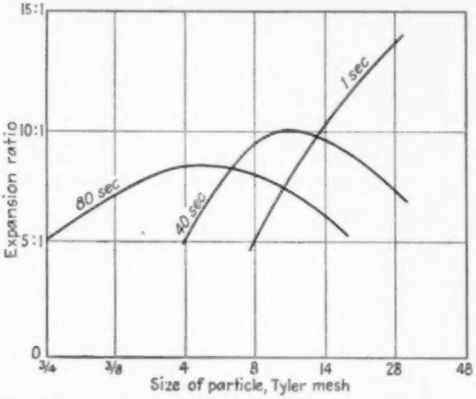


Fig. 2—Expansion ratio of 1650°F perlite versus particle size for different heating times.

Because of greater specific surface, the combined water in finer particles is more likely to be driven off before the softening point is reached. Therefore, if a mixture of coarse, intermediate, and fine perlite is subjected to a certain final temperature after a given heating time, the coarser particles and the finer particles may expand to a lesser degree than the intermediate particles. The coarse particles would fail to expand properly because the heating time was insufficient to bring them up to the temperature necessary for full expansion. The fine perlite would attain less than full expansion because much of its combined water was driven off before its softening point was reached. Fig. 2 shows the relation between expansion ratio and particle size for a 1650°F perlite containing a mixture of sizes and heated at three different rates.

Maximum Temperature Reached: The excess temperature attained above the original softening point of the glass determines the degree of expansion just as does the heating time. Most operators keep the furnace temperature as high as possible without fusing the perlite to the furnace wall in order to expand the coarser particles. This leaves no other means of controlling the expansion ratio except by manipulating the heating time. Attempts to govern the expansion ratio by temperature control alone are not generally successful when a widely sized feed is employed.

Cooling of Expanded Perlite: It has been argued that particles of expanded perlite must be cooled rapidly so as not to allow the escape of the gases which produced expansion, thereby allowing the collapse of the bubbles. There is evidence, however, that expanded perlite is actually quite solid and free of stickiness even at temperatures above that of expansion. A type of perlite rock which expands at 1650° F was placed in a heated vessel and inserted into an electric muffle furnace previously heated to 1700° F. The perlite expanded ten times, presumably going through a soft state during expansion. The product was kept at 1700° F for 10 min, after which it was prodded with a rod. None of the particles were stuck together, and the individual grains were crisp and solid. A possible explanation for this observation is that the release of water from the glass during expansion elevates the softening point and causes the material to resolidify after the water is out of the glass and in the cells. This hypothesis would also explain why the bubbles in expanded perlite are of essentially equal size, whereas the pores in bloated shales are of greatly varying dimensions due to merging of bubbles in the soft mass.

Other Variables: Some believe that in addition to the variables enumerated above, the expansion of perlite depends upon the oxidizing or reducing character of the flame, or upon the pressure or vacuum in the furnace or discharge hood. There is no evidence to support these claims, since perlite expands quite well in an electric muffle furnace, in which the atmosphere is neither oxidizing nor reducing, and the pressure is exactly atmospheric.

Furnace Types

The following furnace types will be discussed: the horizontal stationary furnace with and without a preheater, the vertical stationary furnace with four combinations of feed and draft, the short and the long cocurrent rotary furnaces, the countercurrent rotary, the indirectly-fired rotary, and the multiple-hearth furnace. With the exception of the indirectly-fired rotary, only refractory-lined furnaces are discussed in this paper.

Horizontal Stationary Furnace: The horizontal stationary furnace (fig. 3) or flash furnace as it is sometimes called, consists of a tube 10 to 20 ft long and 6 in. to 2 ft in diameter. The tube is generally refractory-lined and set at a slight angle to the horizontal. The burner and feeder are located at the upper end of the tube, and the lower end is connected by suction pipes to a settling system and a

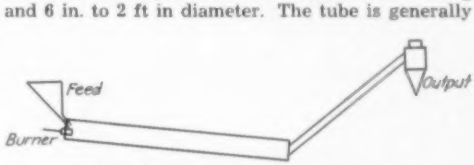


Fig. 3—Horizontal stationary furnace.

suction blower. One type of flash furnace employs a settling tank, a cyclone, a blower, another cyclone, and a bag filter system, in that order. Perlite is dropped into the flame at the hottest point, expands, and is carried out in the exhaust gases. The settling system is usually arranged so that unexpanded material drops out through a reject port, and various products ranging from coarse to fine are separated out in each successive settling device, making screening of the product unnecessary.

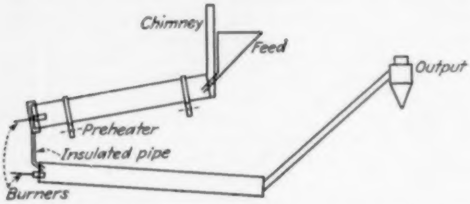


Fig. 4—Horizontal stationary furnace with preheater.

Since the heating time afforded by the flash furnace is never over 2 sec and is often only a fraction of a second, particles of perlite coarser than 14 mesh cannot be properly expanded. Even minus 14 mesh feed must be subjected to a furnace temperature much higher than the softening point of the glass in order to transfer the necessary amount of heat to expand the larger particles. At this high temperature, the finer components of the glass are liable to stick to the walls of the tube or to expand too much, producing an excess of "fly fines" which defy collection and have no large scale uses if caught. For these reasons, it is advisable to use a dead glass which expands properly with a short heating time, sized finely and closely, with neither plus 14 nor minus 48 components. The flash furnace is always a "snow machine" unless a very dead glass is selected.

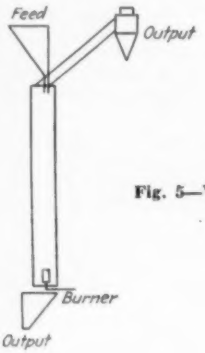


Fig. 5—Vertical stationary furnace.

The big advantage of the flash furnace is that the cost of construction for a given production rate is very low. The fuel consumption, however, is higher than that of any of the other directly fired furnaces, due to the fact that the retention time is too short to allow proper transfer of heat from the gases to the perlite, and because the exhaust gases from the hot zone are not used to preheat the ore.

Horizontal Stationary Furnace with Preheater: The flash furnace with preheater (fig. 4) is operated in the same way as the plain flash furnace, except that the perlite is preheated in a rotary furnace before being dropped into the hot flame of the flash tube. The rotary unit can be either cocurrent or countercurrent, lined with refractory or unlined, and its length can range from 2 to 30 ft. Retention times in preheaters range from 20 sec up to several minutes.

Preheating allows a broader size distribution to be used in the feed, and permits the use of livelier glasses. One possible explanation for these advantages is that preheating: (1) reduces the combined water content and elevates the expansion temperature of the glass, with greater effect on the fines than on the coarser particles, (2) diminishes the effect of thermal shock which causes unequal thermal expansion and mechanical breakage of the glass particles when they hit the hot zone, and (3) heats the larger particles to near the temperature required for expansion, thereby making them more likely to expand when they receive a short flash of high temperature. With proper temperature controls, a preheater offers an extra degree of control over the ratio of expansion, but with a manually set fuel feed, the preheater can actually be a cause of variation in the quality of the product. The use of preheaters with flash furnaces at present is generally limited to small units for the prevention of excessive fines in the product.

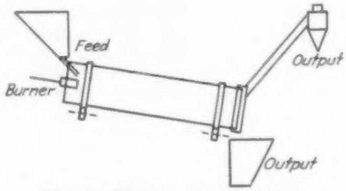


Fig. 6—Short cocurrent rotary.

A small preheater fired with a simple, manually controlled gas burner does not add appreciably to the installation cost of a flash furnace, but larger, more effective rotaries can increase the investment by 50 pct.

Vertical Stationary Furnace: The vertical stationary furnaces discussed here are refractory-lined tubes placed in a vertical position. Many versions of the vertical furnace are possible because the burner may be placed at either the top or the bottom, and the perlite may be fed at either the top or the bottom. The top-fed, top-fired vertical has all of the characteristics of the horizontal stationary furnace, but requires elevation of the feeder and the preheater too, if used, which adds to the installation cost without yielding any appreciable advantages. With the bottom-fed, bottom-fired vertical, the perlite is shot up from the bottom and is supposed to float in the rising stream of hot gases until it is expanded, at which time it will be carried out the top with the exhaust gases.

The top-fired, bottom-fed vertical was tried but the plant did not get into production. The bottom-fired, top-fed vertical is pictured in fig. 5. The burner is at the bottom and the hot gases pass up the tube as in a chimney and leave at the top. The perlite is fed in at the top and drops through the

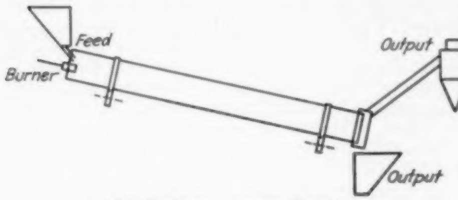


Fig. 7—Long cocurrent rotary.

rising hot gases. The perlite is heated and expanded as it falls until the density of the particles is low enough for them to be caught in the stream and carried back up the tube and out the top. Sometimes this furnace is operated so that part of the material falls on down past the burner. This makes two products: the light fine material which goes up with the hot gases, and the larger heavier particles which drop on down past the burner. Almost any ratio can prevail between these two products, depending upon how the furnace is being operated. Balance in this vertical furnace is very tricky. Large particles with less specific surface tend to fall faster through the rising gases than small particles with more specific surface, yet it is the large particles which should remain in the heat a longer time than the small ones. However, if the draft is set so that all particles eventually do return to the top of the furnace, then the larger particles are exposed for a longer time than the smaller ones because they travel further down before expanding and returning. If there is to be a wide size distribution of particles, the better type of operation for this furnace is for as much of the material as possible to leave the furnace at the top. Considerable difficulty with fusion of hot sticky particles to the walls of the furnace should be expected with this type of vertical. When a particle is in the act of turning around, it has no velocity and is very hot and sticky at that time.

Outside of these special characteristics, the vertical stationary furnace has all of the properties of the horizontal flash furnace. It is a short heating time furnace and, like the horizontal flash furnace, it requires a dead glass if the production of very light and fine material is to be avoided.

Short Cocurrent Rotary: The short cocurrent rotary (fig. 6) is essentially a rotating flash furnace. It is generally from two to four diameters in length and inclined about 1:8. The raw material is fed in at the upper end, usually dropping right through the flame. The hot gases carry the light fine product out of the furnace and it is handled in a cyclone and blower system similar to that used in stationary flash furnaces, but this type of furnace generally produces a fairly large percentage of coarse, heavier material which is not carried out in the gases but drops out at the discharge end of the rotary into a mechanical conveyor which carries it to screens and bins. This coarse product is not caused by the design of the furnace but rather by the use of a coarser feed than is used in stationary furnaces. The retention time in the furnace is not sufficient to expand the coarse particles fully, hence the coarse aggregate made in the short cocurrent rotary is generally heavy, cracked, and discolored.

Due to the slightly longer retention time, the fuel efficiency in a short cocurrent rotary should be a little better than that of the stationary furnaces. Although high production rates are claimed for small furnaces of the cocurrent variety, the installation cost for a given production rate is bound to be higher for a rotary than for a stationary furnace.

Long Cocurrent Rotary: The long cocurrent rotary (fig. 7) is a variation of the short cocurrent rotary. Its length is usually about 8 diam although there is one furnace 13 diam long in production. This extra length allows the operator to play the the flame down the tube so that the hot zone is some distance away from the feed end of the furnace. Then, if the perlite is dropped in under the flame, some preheating can be had before the perlite reaches the hot zone. This preheating does not utilize the exhaust gases, therefore fuel efficiency on a long cocurrent rotary will not be much better than on a short cocurrent rotary.

The longer hot zone usually available in the long cocurrent rotary allows the coarse particles of perlite to be more thoroughly expanded, but the coarse expanded particles are nevertheless heavier than the fines. In the stationary flash and short cocurrent rotary furnaces, the fines expand rapidly and are swept out of the hot zone fast enough to prevent their sticking to the walls. But in the long cocurrent rotary where the perlite is fed under the flame, the fine component gets up to a softening temperature rapidly because of the high furnace temperatures which must be employed to expand the coarser particles in the short time available. These fine melted particles stick to the walls of the tube and start the formation of a ring, which gets hotter and hotter and finally picks up large particles as well. One remedy for this condition is to drop the perlite through the flame, as in a short rotary, but then most of the advantage of the length of the furnace is lost. Another alternative is to remove the finer component from the feed.

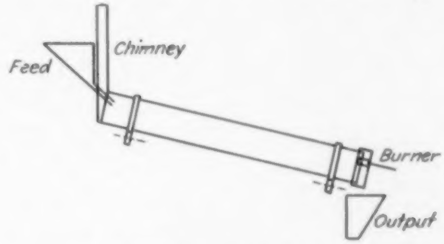
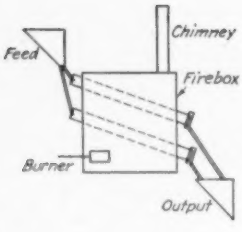


Fig. 8—Countercurrent rotary.

Long Countercurrent Rotary: The countercurrent rotary (fig. 8) is a conventional rotary furnace and



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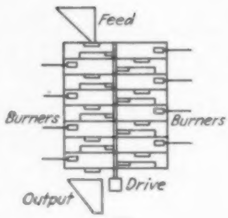

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Fig. 9—Indirectly-fired rotary.

Fig. 10—Multiple-hearth furnace.

is operated in the conventional way. It is usually refractory-lined for more than 4 diam of its length, and set at a slope of 1:8. The burner is at the bottom of the tube, and the hot gases travel up the tube by convection and out a chimney at the top. The perlite is fed in at the top end, and is gradually heated by the exhaust gases as it rolls down the tube toward the hot zone, which is at the lower end. It expands in the hot zone and drops out at the bottom of the furnace. The exhaust gases at the top end are not over 800°F and their velocity is generally kept as low as possible to give good fuel efficiency and to prevent carrying any of the expanded perlite back up the furnace. In this furnace, heating time is about the same as retention time, and this time can be adjusted by changing the slope or the rotation speed of the tube, or both. Closer temperature control is possible with this type of furnace than with short heating time furnaces because the long heating time available obviates the necessity for furnace temperatures much in excess of the expansion temperature of the perlite. Due to ease of adjustment of retention time and good temperature regulation, the size distribution and density of the product may be closely controlled. Fusion of perlite to the walls is easily prevented, and the long retention time (20 sec up to several minutes) keeps the fines from flying apart into light dust. No dust separators are needed.

A big advantage of the countercurrent type of operation is its good fuel efficiency. As the hot gases travel up the tube from the hot zone, they transfer heat to the colder particles of perlite, so that by the time the perlite arrives at the hottest zone, it has already been preheated to almost the final temperature. At the same time, the hot gases which leave the tube at the upper end have transferred much of their available heat to the bed of perlite. Fuel consumption as low as 2½ million Btu per ton has been reported with a countercurrent rotary of 8 diam long, and the efficiency could be improved a little if the tube were longer.

A disadvantage of the countercurrent rotary is that high expansion ratios can be obtained only with very lively glasses. With a 1 min heating time only relatively few types of perlite can be expanded to ratios greater than ten to one. Another disadvantage is the low production capacity for furnaces of a given size and cost. A countercurrent furnace 30 ft long by 3½ ft id is only good for two thirds of a ton per hour. The best use for a countercurrent rotary is in the expansion of perlite to pieces larger than ⅛ in. It is possible to expand some very lively glasses into pieces up to 2 in. long with a density of less than 10 lb per cubic foot.

Indirectly-fired Rotary: The indirectly-fired rotary (fig. 9) is an unlined tube made of heat-resisting but heat-conducting material, usually stainless steel. It is generally over 4 diam in length and capable of variable inclination. It is enclosed in a firebox which supplies the heat for one or more such tubes. Each tube has its own feeder, and as the perlite rolls down through the tube it is heated by conduction through the walls of the tube. Fusion of the perlite to the walls of the tube is avoided because none of the particles is overheated as is the case when perlite is fed directly into an open flame. Lack of extreme temperatures and fairly long heating times prevent the formation of dust. Retention time can be varied, and usually runs between 5 and 60 sec. Poor fuel efficiency should be expected in an indirectly-fired furnace, and difficulty with the steel tube will result if too high a temperature is reached. The installation cost of an indirectly-fired furnace is even higher than for a countercurrent rotary for the same production rate, and very lively glasses must be used to provide good expansion ratios.

Multiple-hearth Furnace: With the multiple-hearth Wedge-Herreshof ore-roaster, (fig. 10) perlite is fed in at the top of a series of hearths arranged one above the other, and progresses from one level down to the next with the aid of scrapers. Flames on the various levels provide any desired time-temperature curve, giving excellent expansion of coarse pieces of lively perlite. This type of furnace has all the advantages and disadvantages of the countercurrent rotary but in addition its installation cost is more for a given production rate.

Summary

Table I summarizes this paper and the authors' opinions on each of eight furnaces with regard to nine operating characteristics.

Table I—Summary of Furnaces and Operating Characteristics

Detailed Evaluation of Performance of Various Types of Furnaces	Horizontal Flash	Horizontal Flash with Pre-Heater	Vertical Stationary	Short Cocurrent Rotary	Long Cocurrent Rotary	Countercurrent Rotary	Indirectly Fired Rotary	Multiple Hearth
Fuel efficiency	Fair	Fair	Fair	Fair	Fair	Good	Poor	Good
Freedom from waste dust production	Poor	Fair	Poor	Poor	Fair	Good	Good	Good
Production for a given construction cost	Good	Fair	Fair	Fair	Fair	Poor	Poor	Poor
Ability to make light plus 8 mesh product	Poor	Poor	Poor	Poor	Fair	Good	Good	Good
Ability to make light minus 8 mesh product	Good	Good	Good	Good	Good	Poor	Poor	Poor
Ability to expand low temperature ores	Poor	Fair	Poor	Poor	Fair	Good	Good	Good
Ability to expand high temperature ores	Good	Good	Good	Good	Good	Poor	Poor	Poor
Ability to avoid fusion of perlite to walls of furnace	Fair	Fair	Poor	Fair	Fair	Good	Good	Good
Control over size distribution and degree of expansion	Poor	Good	Poor	Poor	Fair	Good	Good	Good

Notes on the

Geology of the Potash Deposits

of Germany, France, and Spain

Permian salt measures carry extensive lenses of soluble potash salts in north central Germany. Potash deposits of Oligocene age are found in the Upper Rhine Graben of Alsace (France), and in the Catalonian Basin of Spain. These deposits are found in a wide range of structural settings. Reserves are large, and the production of potash salts is an important phase in the economy of each of these countries.

by J. P. Smith

DURING the winter of 1946 to 1947 potash operations in Germany, France and Spain were visited by the author. The U. S. Department of Commerce, through its Field Intelligence Agency Technical, sponsored the inspection of German properties by representatives of the American Potash Industry.

Vast deposits of potash salts occur in the abovementioned countries, and the production and marketing of these salts are important in their respective economies.

Germany

An area of some ten thousand square miles of north central Germany is underlain by lenses of potash salts interbedded with greater thicknesses of sodium chloride or common salt. These salt measures are relict deposits from the evaporation of an arm of the Zechstein (Permian) Sea which formerly covered northern Europe. During the peak year of 1940, Germany produced salts containing 1,860,000 tons of K_2O and, next to coal, potash is its most important mineral raw material.

The German deposits are found in the synclinal areas flanking the Flechtingen, Hartz Mountain and Thuringian uplifts, and, to the north they lie beneath the plains of Hannover. The regional dip of the salt measures is to the north, hence, lenses of potash found at depths of 500 to 1000 m* in the South Hartz or Stassfurt Districts should be expected at depths exceeding 3000 m in the vicinity of Hannover. However, local doming of the salt has brought the overlying potash beds upward, and, at the flanks of certain domes, the potash beds are 100 m and less beneath the surface.

* For conversion of meters to feet see table at end of paper.

Two general depositional provinces of potash concentrations are recognized: (1) the main basin, and (2) the subsidiary basin. The main basin embraces the producing districts of Stassfurt, Sud Hartz, Halle, and Hannover-Braunschweig. From 40 to 45 pct of the German production comes from this basin. The Werra-Fulda district, producer of 50 pct or more of the German potash, lies in the subsidiary basin.

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TP 2621 H. Discussion of this paper (2 copies) may be sent to Transactions *AIME before Feb. 28, 1950. Manuscript received May 26, 1948.*

Salt Stratigraphy: Five commercial potash zones or beds are recognized. The three beds present in the main basin are: The Stassfurt bed that occurs near the top of the older salt, and the Ronnenberg and Riedel beds in the younger salt occurring 200 to 300 m, respectively, above the Stassfurt bed. The Stassfurt bed is found over the entire main basin, while the Ronnenberg and Riedel are restricted to the Hannover area.

Two potash beds occur in the Werra basin. These are the Thuringian, or lower bed and the Hessen or upper potash bed that occurs 60 m above. These beds lie 210 and 150 m, respectively, below the position of the Stassfurt bed, and are restricted to the Werra basin. The upper bed is 2.5 to 11.5 m in thickness, and the principal ores are hartsalz with varying thicknesses of carnallite. The lower bed averages 3 m in thickness, and contains hartsalz. The upper bed is presently being mined, and the

lower zone is held in reserve. The younger salt is missing over the Werra basin.

More than thirty saline minerals have been identified from the German section of evaporites. The commercial potash beds are admixtures of sodium chloride (common salt) with varying proportions of the potash salts. These are termed raw salts. The principal raw salts mined are: (1) Sylvinite—sylvite (KCl) and halite (sodium chloride), this raw salt averages 10 to 20 pct K_2O. (2) Hartsalz consists of sylvite, halite, kieserite (magnesium sulphate) and anhydrite (anhydrous calcium sulphate) and averages 10 to 15 pct K_2O. (3) Carnallite raw salts consists of carnallite (potassium and magnesium chloride) and halite, and averages 8 to 12 pct K_2O. The raw salts in the German mines are white, gray, or buff in color, and are distinguished with difficulty from the enclosing salt. Lateral gradation from sylvite to hartsalz to carnallite may suggest changes from marginal to basinward facies of deposition.

The deposits of the Werra district are relatively flat lying, and are characterized by regularity of thickness, tenor of K_2O, and distribution. Locally, these beds are cut by sills and dikes of basic igneous rocks.

The deposits of the Hannover district are steeply dipping, irregular in extent, thickness, and grade. In the upbuilding of the Hannoverian salt stocks, the more plastic carnallite, sylvite, and hartsalz have been squeezed into available voids. These potash salts are concentrated in the synclinal lobes on the flanks of the salt core. All variations, from conformable salt anticlines to extreme diapir or piercement type doming are represented in the German salt stocks. An example of piercement, on a relatively small scale, was seen at the Bad Salzdetfurth salt stock (fig. 1). On the northeast flank of this dome, the hauptanhydrite, a competent member of 75 m thickness, has been breached, the underlying Stassfurt (carnallite) bed, has been squeezed upward, piercing 100 m of salt, and has been brought into direct contact with the Ronnenberg (sylvinite) bed.

The flat lying Werra deposits are mined by room and pillar system. About 60 pct of the ore is removed without backfilling. The mines visited showed little evidence of subsidence, despite the fact that the pillars were supporting from 1200 to 1600 ft of overburden. For an excellent description of the details of mining, you are referred to a paper by East.[1]

The Hannover deposits are mined by stoping and backfilling. Vertical hoisting shafts are sunk in the salt core, and drifts driven to the flanks. Much underground prospect drilling is necessary in following these beds. Because of high rock temperatures and pressures, little mining is done below depths of 800 m. Ground water conditions have discouraged mining operations at depths of less than 400 m, as several mines have been lost by flooding.

Waste salt disposal is a problem at the German potash plants. The law prohibits raising the chloride content of the streams above a concentration of 2000 parts per million, hence limited quantities of salt can be dumped into the streams. In the Werra district, waste brines are injected, through boreholes, into the laminated dolomite (Permian) which overlies the salt measures. From 1000 to 1300 gal per min of brine is disposed of in this manner at an individual plant. In the Hannover district, there is no porous formation to receive the waste brines, here the waste salt is partially dried, and sent underground for backfill or stock piled on the surface.

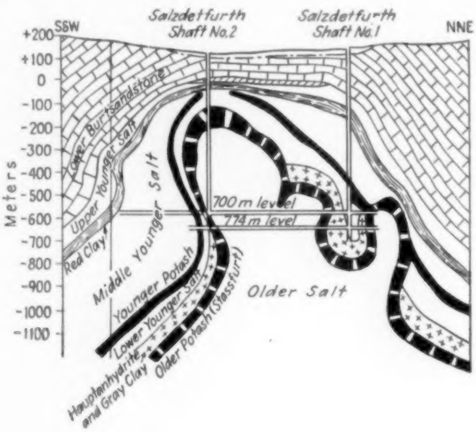

Fig. 1—Profile of salt stock, Bad Salzdetfurth, Germany. Cross-section showing deformation of salt and potash beds.

(After E. Fulda, 1935)

Prior to 1921 there were some 220 operating mines in Germany. In recent years, all but the low cost operations have been shut down. At present, only 25 mines are being operated. Under the present occupational zoning, the productive areas are divided as follows: Russian Zone, 61 pct; British Zone, 22 pct; American Zone, 14 pct; and French Zone, 3 pct.

The 10 most productive mines are in the Werra and South Hartz districts. Two of these are in the American Zone, and eight are in the Russian Zone. Kaiseroda (Russian Zone) is the largest mine, having a hoisting capacity of 7000 tons of raw salts per day. In terms of total K_2O processed, it compares with the individual mining operations in New

Mexico. The two mines in the American Zone are Wintershall and Hattorf. Both mines have hoisting capacities of 5000 to 6000 tons of raw salts per day. In December 1946, these plants were operating at 45 pct capacity. Hartsalz is the principal mineral exploited at these plants. The hartsalz averages 3 m in thickness and 11 pct K_2O. A carnallite bed of varying thickness, directly overlies the hartsalz at Wintershall. Metallic magnesium was formerly produced by electrolysis of molten carnallite at the Wintershall plant. During peak production years the output of the Wintershall operation was of the order of 6000 to 7000 tons of magnesium metal per annum.

The total reserves of potash in Germany have been estimated as being of the order of 20,000,000,000 tons of K_2O. This is sufficient to last for 1000 years at the former peak rate of production. Much of this reserve lies at depths too great to be economically exploited by present day techniques.

The solution and crystallization process of refining is used throughout Germany. Since the war, considerable experimental work on the flotation treatment of potash salts has been done. Potassium chloride containing 40 to 50 pct and 60 pct K_2O are the principal processed products. Sulphate of potash is an important product where hartsalz is mined. Many of the refineries produce bromine in limited quantities as a byproduct. Shortages of food, coal, equipment, and trained labor, with inadequate transportation facilities are responsible for holding present production to 60 pct of the capacity.

France

The Alsatian potash basin (fig. 2) is situated immediately north and east of the important manufacturing city of Mulhouse, in the upper Rhine Valley. The production area is oval in shape, and occupies an area of approximately 75 square miles. Two workable beds of sylvite raw salts are found over much of this area. The upper bed averages about 1.5 m in thickness and covers about half of the productive area. The lower bed averages 4 to 4.2 m in thickness and covers an area of about 65 square miles. An extension of the lower bed is found near Buggingen (Baden Province, Germany) on the east side of the Rhine. The Buggingen deposits are the only known Tertiary potash deposits in Germany and are the richest sylvite beds in that country.

The Alsatian potash deposits are of (Sannoisien) Lower Oligocene Age, are contemporaneous with the Catalonian (Spanish) deposits and are much younger than the Permian deposits of New Mexico, Germany, and Russia. They occupy a fault basin or "graben" in the upper Rhine Valley. This part of the Rhine Valley is very flat, and is faced by the steep fault scarps of the Vosges Mountains in France and the Schwarzwald (Black Forest) of Germany. These mountains are capped with much more than ancient rocks (Jurassic), that represent remnants of the anticlinal arch that once was continuous across the Rhine Valley. The present valley is floored by Quaternary sands and gravels. These are underlain by Tertiary rocks that carry rock salt and the potash beds.

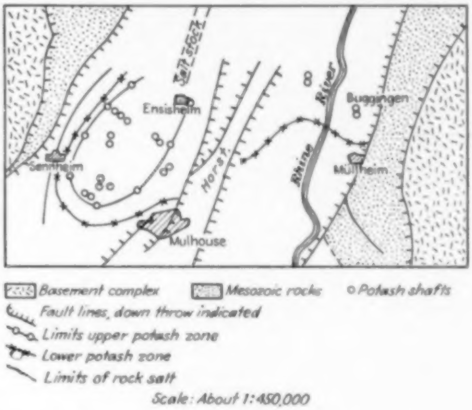

Fig. 2—Map of Alsatian potash basin.
(After F. Lotze[4].)

The section at the Marie Louise Shaft follows:

Quaternary	Valley Fill	0 to 22.3 m
Upper Oligocene Chattien	Limy Sand Fish Shale Marl	22.3 to 77.4 m
Middle Oligocene Stampien	Gypsum Limnae Zone Dolomite Anhydrite and Rock Salt	77.4 to 236.4 m
Lower Oligocene Sannoisien	Upper Bituminous Zone with Rock Salt and Potash Fossiliferous shale Lower Bituminous Shale and Rock Salt Conglomerate Zone with Rock Salt	236.4 to 700 m

More than 200 borings have been made in the general area, only four of which have been drilled through the Oligocene. The greatest thickness of Oligocene penetrated was in the boring D.P.II near Schoensteinbach. This well entered the Sannoisien at 40 m and bottomed at 1650 m in rocks carrying

salt in the basal Sannoisien. Shales and marls, rich in marine-type fossils are found intercalated with rock salt short distances above and below the potash beds. The area has had a complex depositional and structural history.

The potash beds are prominently banded. An exposed face shows alternating bands, more or less wavy, of white and red sylvite salts. The banding is accentuated by paper thin shales that separate the varicolored salts. The top and bottom of the workable potash zones are demarked by prominent dark shale beds. The banding and layering aids the breaking and extraction of the ore. It also adds some element of hazard, as rock falls are common.

The saucer like basin is roughly oval, bulging to the south, and restricted as a relatively narrow neck to the north. The dips are to the center of the basin from east and west, with gentle overall tilting to the north. The north end of the basin is further complicated by a narrow north-south trending salt anticline or "Sattel." The potash beds are not continuous across this sattel.

The regularity and gentle attitude of the beds favors large scale exploitation. Mining is done by longwall and modified room and pillar systems.

Fifteen shafts and six refineries were in operation in early 1947. For the current year production equaled or exceeded that of the peak years 1941 to 1943, and was of the order of 650,000 tons of K_2O. Processing by solution and crystallization is used by all the refineries. Flotation equipment has been purchased, and future plans call for the use of this method in some of the plants. Potassium chloride of 50 and 60 pct K_2O grades are the principal products of the refineries. Limited amounts of bromine are produced as a byproduct. Reserves of the Alsatian field, including the deposits of Buggingen, are of the order of 300,000,000 tons of K_2O.

The potash deposit at Buggingen (Baden), Germany, is an eastward offshoot of the main Alsatian basin. The workable zone covers an area of 0.56 square miles, and varies from 0.5 to 4.0 m in thickness. The principal bed is exploited through two vertical shafts, and the main level of mining is 800 m below the surface. These deposits dip from 18 to 20° to the northwest, and are mined by modified room and pillar system. The production is small, as the hoisting capacity is of the order of 200 tons of raw salts per day.

Lenses of potash salt, of Triassic age, are found in southwestern France near Bayonne and Dax. More than thirty boreholes have been sunk in this area. The salt and potash beds are highly contorted. A record of one borehole south east of Dax shows a 7 m zone (from 762 m to 769 m) that averages 10.77 pct K_2O. The small mining operation in this district has recently been discontinued because of the erratic occurrence of the beds and the high cost of operation.

Spain

The principal Spanish potash basin is some forty miles north and west of the Mediterranean seaport of Barcelona. The potash beds are of lower Oligocene age and occur near the top of thick salt measures. Outcrops of Eocene rocks in the vicinity of the towns of Vich, on the east, Balaquer to the west, Isona and Berga to the north, and Manresa on the south delimit this basin. The total area of this basin is some 1200 square miles, but the workable potash beds are confined to the depositional center. Several east-west trending anticlinal axes extend across this basin and prospecting has been confined to these anticlines. Claims covering 350 to 400 square miles have been granted to concessionaires.

Overlying the potash beds are varying thicknesses of rock salt and gypsum, followed upward by marls, clays, and siltstones. In the deeper part of the basin the potash beds are overlain by 150 to 200 m of salt, in the shallower portions of the basin, the potash beds occur near the top of the salt measures. A basal anhydrite member separates the evaporates from the fossiliferous marls and limestones of the underlying Eocene rocks.

This interior basin is bounded on the west by the midland plateau of Spain. To the east it is bounded by the rugged coast range, an upfaulted mass of Mesozoic and Paleozoic rocks, and to the north it is bounded by the upfolded older rocks of the Pyrenes Mountains. According to European geologists, the forces that gave rise to the building of the Pyrenes Mountains began in the Eocene and reached a maximum during Oligocene times. During Oligocene, the Catalonian basin was occupied by a gulf or continental sea connected by narrow waterways to the ocean. The evaporation of these waters has produced the salts of the present basin. Salt and potash deposits of Triassic age are found near Bilbao and elsewhere in Spain. It has been suggested that leachings from these ancient salt measures may have contributed increments of potash to the brines that produced the evaporites.

Doming and faulting have brought the salt to the surface at Cardona. The famous salt mountain represents a local eruption superimposed on the anticlinal axis. Thrust faulting has brought the potash beds to 50 m below the surface at Suria. Anticlinal folding has brought the potash beds upward at Sallent.

A study of the Spanish deposits is a classic example of the behavior of plastic rocks that have been subjected to various intensities of folding. There are numerous examples of gliding and wrinkling of the more plastic carnallite and sylvinite beds. Sr. Marin has suggested that the potash salts are not only plastic but may also be considered as semi-dynamic or catalytic, that is, where present in considerable thickness they may serve to localize or initiate structural activity.

Two zones of soluble potash minerals are recognized in the moderately disturbed section at Sallent. At the top is a carnallite zone 8 to 10 m thick, carrying from 40 to 60 pct of carnallite. Directly underlying the carnallite is the sylvite zone. This consists of two beds of sylvinite given in descending order as follows:

	Thickness	K_2O, Pct
Bed B sylvinite	0.8 m	23.0
Salt Bank	2.5 m	
Bed A sylvinite	2.7 m	23.8

The potash salts are red in color and are prominently banded.

Folding at Sallent is moderate and is of open type (fig. 3). Folding at Suria and Cardona is intense, and is complicated by overturned folds, shearing,

Fig. 3—Interior of mine showing local folding in sylvite.

(Courtesy of Potasas Ibericas, S.A., Sallent, Spain.)

and faulting. The potash beds at Suria and Cardona have been thickened by duplication of beds. Local impoverishment and enrichment is characteristic. Mining at Sallent is by modified room and pillar system with backfill. The salt bank, referred to above, is first mined and used for pack walls, the upper sylvite bench is then taken, and, finally the lower bench. Refinery tailings and barren salt are used for backfill. At Cardona and Suria variations of stope mining with backfill are employed.

Three companies are in operation at present with total daily production of 2900 tons of raw salts. These are Potasas Ibericas (Sallent), Union Espanola de Explosivos (Cardona), and Minas de Potasa de Suria (Suria). A fourth operation, Explotaciones Potasicas (at Balsareny) was scheduled to begin hoisting by the end of 1947. The total annual production of processed salts is of the order of 150,000 tons of contained K_2O. Shortages of coal and equipment, inadequate transportation and nominal domestic consumption of potash have served to hold down the production of potash. With minor changes, the Spanish operators could double the present output.

The combined reserves of these four concessions has been estimated at 143,000,000 tons of K_2O. A total of 1,800,000,000 tons of K_2O is claimed for the entire basin.

Solution and crystallization is the important method of refining used throughout Spain. Within the past six months, a flotation plant capable of producing 25 tons per day has been operated by Potasicas Ibericas at Sallent.

Conversion of Meters to Feet (rounded off to nearest tenth)

Meter	Feet	Meter	Feet
0.5	2	100	328
1.5	5	150	492
2.5	8	200	656
3	10	210	689
4	13	236.4	776
4.2	14	300	984
7	23	400	1,312
8	26	500	1,641
10	33	700	2,297
11.5	38	762	2,400
22.3	73	769	2,523
40	131	800	2,625
50	164	1,000	3,281
60	197	1,650	5,414
75	246	3,000	9,843
77.4	254		

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California Talcs

by Lauren A. Wright

The principal talc deposits in California are in a 200-mile belt paralleling the state's eastern border. The southernmost deposits represent selective alteration of early pre-Cambrian (?) carbonate strata, and are associated with granitic rocks. Deposits in the Death Valley area are at or near contacts between late pre-Cambrian carbonate rocks and diabase sills. Those in the Inyo Range area are chiefly alterations of Paleozoic carbonate rocks and silica rocks. Most of the state's talc output is used in ceramics.

SINCE the early nineteen-thirties the production of talc* in California has increased five-fold to a yield in 1947 of about 76,000 tons (fig. 1); consequently the state is now one of the nation's three principal talc producers. The 1947 output, which represented about one-sixth of the national total for that year, was approximately equal to production from Vermont, and was second in value to that from New York. New York has an annual output of about 130,000 tons.

Three factors have been mainly responsible for the expansion of talc production in California. (1) Technical advances and innovations, particularly in the ceramic industry, have increased the demand for certain California talcs. The nation's high-quality steatite, used in the manufacture of high-frequency insulators, is obtained largely from sources within the state, as are the tremolitic talcs that are used as the principal ingredients in nearly all of the floor and wall tile manufactured on the Pacific Coast. (2) World War II brought added impetus to the industry, mainly through demand for the urgently needed steatite. Fibrous talc, used as a paint extender by the armed forces, also was produced in quantity. (3) Expanding western industry has continued to draw heavily on California talc deposits, and has extended the upward production trend into the postwar period.

Considerably more than half of California's current talc output is used as ceramic raw material. The paint, rubber, paper, and textile industries are the more important consumers of the remainder. Smaller amounts are used as insecticide carriers, and in cosmetics, and various minor industrial applications. During World War II the principal steatite deposits were studied in detail by members of the U. S. Geological Survey; other sources of commercial talc in the state have in the past received but scant geologic attention. The following discussion is essentially a preliminary report based on research currently in progress by the California Division of Mines, and includes a brief outline of previous steatite studies by the U. S. Geological Survey.

Distribution of California Talc Deposits: The principal talc resources of both California and Nevada are confined to an elongate belt that extends from the vicinity of Baker, in north-central San Bernardino County, northwestward to include the southern Death Valley region, the Inyo Range, and the Palmetto-Oasis district of western Nevada (fig. 2). This belt, of which all but the northernmost tip lies in California, is approximately 200 miles long and 30 miles in average width.

Included in the belt are four contrasting areas. The deposits within each area are geologically similar and yield talcs that have characteristic properties and applications. Three of these local "talc provinces" lie within California's portion of the talc-

* Unless otherwise qualified, the term "talc" in this paper will imply a mixture of the pure talc with such related minerals as commonly occur in the commercial material.

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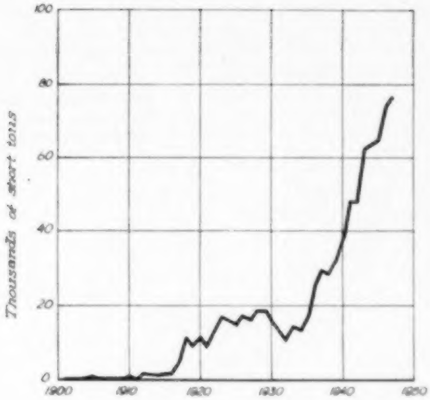

Fig. 1—Talc production in California.

bearing belt. The southernmost is centered north and east of Silver Lake, in north-central San Bernardino County. A second, immediately to the northwest, includes the southern Death Valley area and the Kingston Range, and lies in both San Bernardino and Inyo Counties. Deposits of the third province are best represented by a group of mines east of Keeler, in Inyo County, but similar deposits are scattered on both sides of the Inyo Range to the north. These three areas are here referred to as the Silver Lake, Death Valley, and Inyo Range talc provinces.

The fourth and northernmost province is in Esmeralda County, Nevada, east of the California-Nevada line. The talc deposits are confined to a relatively small area that is crossed by the highway connecting Oasis, California, with the old Palmetto mining district, Nevada; the name "Oasis-Palmetto talc province" has been applied to the area. Most of these deposits are alterations of dolomite; the talcs are used chiefly as cosmetic material and are milled in southern California.

A second talc-bearing belt comparable in size to the one described above and with a similar trend lies within the western foothills of the Sierra Nevada. For many years talc and talcose material have been produced under the name "soapstone" from numerous small operations in this area. The output has been consumed largely in the manufacture of roofing material, and has been produced in much smaller quantity than the talcs of eastern California. A small talc and soapstone production has also been obtained from other, widely scattered California deposits.

The history of California's talc industry to date has evolved largely around three properties, each in a different talc province of the eastern belt. These, from south to north, are the Silver Lake, Western, and the Talc City mines (fig. 2). All were opened during the period 1915 to 1917, and since that time they have yielded more than 500,000 tons of talc, or approximately two-thirds of California's total talc and soapstone production. According to records of the California Division of Mines, the remaining tonnage has been obtained from 53 other properties, 30 of which are in the eastern belt, 17 in the western Sierran foothills, and 6 at scattered points throughout the state.

At present mining is centered in the eastern belt, where 11 properties, including the three previously mentioned, have been in relatively continuous operation; 13 others were worked earlier or have been intermittent operations. At least three deposits are scheduled to be worked for the first time within the next year or two; and the exploitation of still others must await more favorable economic conditions than now exist. Space does not permit discussion of each property here, but the following brief descriptions of the Silver Lake, Western and Talc City mines should serve to outline the geological features that are characteristic of most in the respective provinces.

Descriptions of Representative Mines

Silver Lake Mine: *Location and Production History:* The Silver Lake mine workings have been developed in a group of elongate talc-tremolite lenses that trend eastward. These are exposed along a narrow, two-mile zone in the hills east of the Silver Lake playa and about ten miles north-northwest of Baker, San Bernardino County. Since 1918, when the property was first worked, a total of approximately 140,000 tons of talc and talc-tremolite rock has been produced. Early mining was confined largely to the western 5000-ft portion of the zone. More recently, a talc body at the easternmost end of the zone was outlined by diamond drilling, and subsequently this body has yielded about 30,000 tons of commercial material.

Geology: The principal talc-tremolite concentrations lie within a relatively thin, but persistent diopside- and feldspar-rich member of a series of highly metamorphosed sedimentary rocks (fig. 3). The series has been briefly described by W. J. Miller[1] who has tentatively dated it as early pre-Cambrian. The more prominent rock types include vitreous quartzite, quartz-muscovite, and quartz-biotite schists, limestone, and granulite. The diopside-feldspar rock which encloses the talc-tremolite bodies also includes phlogopite, quartz, calcite, and

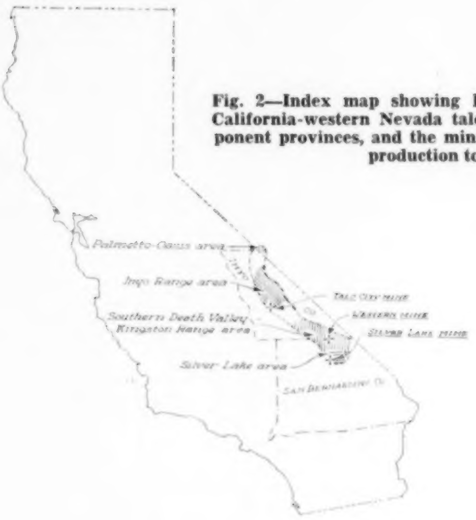

Fig. 2—Index map showing location of the eastern California-western Nevada talc-bearing belt, its component provinces, and the mines that have the largest production to date.

garnet as locally prominent mineral constituents. These minerals, in differing proportions and textural relations, form granulitic, schistose, gneissic, and quartzitic rock types as variants of the member.

In the western portion of the talc-bearing zone the metasediments dip moderately to steeply southward, and are successively offset by a series of cross faults. Toward the eastern end of the zone the metasediments are, in general, intricately faulted. The easternmost talc bodies are in a structural block characterized by gentle folds, but bordered on the west, south, and east by highly brecciated and faulted rocks.

The relatively simple structural features that characterize most of the talc-bearing zone, however, have been greatly complicated in detail by a wide variety of igneous rocks in the form of dikes, sills, and irregular masses. These rocks range in composition from mafic to felsic. Quartz-diorite is the most widespread type but lamprophyric rocks, in both dikes and larger, irregular masses, also are common. Small pegmatitic bodies are abundant, especially in the diopside- and feldspar-rich unit that encloses the talc-tremolite masses.

The main talc-tremolite bodies in the western part of the area are remarkably uniform in their internal structure, as well as in their stratigraphic position. They represent a nearly complete selective alteration of carbonate rocks, presumably of dolomitic composition. A persistent massive limestone in the associated metasedimentary sequence is barren of commercial talc or tremolite, but does contain abundant, though dispersed, olivine, chrondrodite (?) and talc. Diopside has locally replaced this limestone along fractures.

The commercially exploitable talc-tremolite masses are generally 10 to 15 ft thick and as much as 800 ft long. Two of these commonly parallel each other, and are separated by a 5 to 10 ft thickness of diopsidic wall rock. All the talc-tremolite masses in the western area dip about 65° southward. Some are terminated by cross faults, but more commonly they lense along the strike into talc- and tremolite-poor rock or end abruptly against granitic rocks. The contacts separating talc-tremolite rock from diopside- and feldspar-rich wall rock are very sharp in most places. The steeply-dipping deposits have proved disappointingly shallow; the longest mass, which is 800 ft long, was bottomed in a granitic rock at a depth of less than 200 ft.

Tremolite is a major constituent of most of the material currently marketed, and is commonly more abundant than the mineral talc. This is particularly true of the rock that occurs near the hanging walls of the steeply-dipping bodies. Most of the tremolite-poor talc concentrations in these deposits are adjacent to the footwall and are only several feet thick. Smaller and less continuous seams of the mineral talc occur within the tremolite-rich material and are locally adjacent to the hanging wall. The greatest thickness of relatively pure talc, however, was removed from bodies in the gently folded metasediments to the east. Here this talc is reported to have had a maximum thickness of 40 ft.

Mining Methods: Mining operations at Silver Lake have followed a relatively simple pattern. The steeply-dipping deposits have been developed at the six localities where surface exposures of talc-tremolite rock were most extensive. In common procedure, a shaft is sunk to the keel of the deposit. Drifts are driven to the along-strike limits of the ore body at several levels, and the talc is removed by overhand stoping and hoisted to the surface.

Much material has, however, been removed from the largest body by tramming from an adit. The ground is unusually solid and little timbering is required (fig. 4). In the gently dipping deposits to the east a modified room and pillar method of mining was employed and, recently, a considerable tonnage has been removed from here by open cut methods.

Uses: The earliest production, intended mainly for the cosmetic market, was from the tremolite-poor, talc-rich portions of the deposits. Later, the paint and rubber industries were the principal consumers. Currently most of the ore is marketed as a ceramic material. As tremolite has proved a desirable wall-tile ingredient, the high-tremolite rock, formerly avoided, has become commercial.

Other Active Properties in Silver Lake Area: The two other active mines in the Silver Lake province are in the vicinity of Yucca Grove, on the Baker-Las Vegas highway, and are 12 airline miles north-northeast of the Silver Lake mine. These, the Calmasil and Pomona mines, were opened within the past ten years. Here, as at the Silver Lake mine, talc is an alteration of carbonate strata in a terrane of steeply dipping metasedimentary rocks. Here, also, granitic rocks are extensively exposed. The talcs, too, are tremolitic and are marketed principally as ceramic materials.

The Western Mine: *Location and Production History:* The Western talc mine is about 25 miles due north of Silver Lake and seven miles east-southeast of Tecopa, a small settlement in Inyo County. The mine workings are immediately south of the northern San Bernardino County line. Production, which dates from 1917, now totals well over 150,000 tons, most of which has come from a single ore body.

Geology: The geologic setting of the Western mine (fig. 5) closely resembles that of all of the numerous talc deposits scattered throughout the 1000 square miles of the Death Valley talc province. All of the commercial deposits thus far examined by the author involve similar rock types, and all have been formed at nearly the same stratigraphic position. The only noteworthy differences are in structural and mineralogic details. The talc bodies are confined to the lower portion of the lowermost carbonate member of a late pre-Cambrian sedimentary sequence. At each of the observed properties a diabase sill also is present, and is either in contact with or proximate to the talc bodies.

The carbonate member, characteristically a dolomite, is part of the Crystal Spring formation as defined by Hewett.[2] At the Western mine this member is underlain by about 1000 ft of vitreous quartzite and shale, which in turn overlies, with probable fault contact, pre-Cambrian schist and granitic gneiss. The lower members of the Crystal Spring formation at this locality (fig. 6) are representative of the sedimentary units exposed at all of the active talc mines in the southern Death Valley-Kingston Range area.

Current operations at the Western mine are confined to a north trending talc-tremolite zone that is continuously exposed for a length of more than 5000 ft and a width of 20 to 90 ft. The deposit lies almost entirely along the contact between the diabase sill and the overlying siliceous dolomite; masses of green altered rock, however, form local septa between the talc and the diabase near the south end of the deposit. All units dip moderately eastward. The Western deposit is the largest California talc body that has been extensively developed. Talcose zones of comparable or greater length are commonplace elsewhere in the Death Valley talc province, but none of these are known to have as continuous a body of commercial material.

Parts of the Western deposit consist chiefly of tremolite. Like the tremolite-rich material of the Silver Lake deposits, this rock became marketable only when its value as a ceramic material was

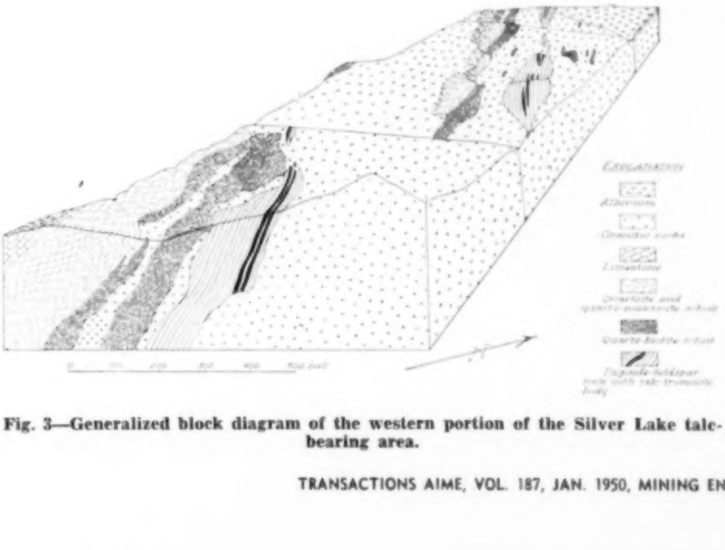

Fig. 3—Generalized block diagram of the western portion of the Silver Lake talc-bearing area.

Fig. 4—Typical stope in the Silver Lake mine.

realized. At the Western mine there are three principal talc types which are mined separately, but are blended in the mine bins prior to shipment. The blended talc is used largely for ceramic purposes.

One talc is compact and evenly laminated, consisting of tiny unoriented tremolite needles; one is nearly pure talc; the third is a mixture of talc, tremolite, and serpentine.

The compact talc occurs in a well defined zone that, where present, lies next to the diabase footwall with a knife-like contact. This talc is currently mined from a mass 1200 ft long and averaging 10 ft wide in surface exposure.

The other talc types are irregularly distributed, and commonly occupy the entire width of the ore body. Fingers of these types extend into partly altered hanging wall dolomite. Elongate masses of altered wall rock are common as inclusions in these talcs.

Though the structure of the Western deposit itself is rather simple, the area, as described by Noble[3], has been subjected to intensive, late Tertiary faulting. In the Western mine area, fault movements have been partly along the relatively weak talc-rich layers. Consequently the less competent portions of the main ore body and the dolomite near the hanging wall are ordinarily sheared and brecciated. Mining, therefore, has been mainly in "heavy ground" that has required much timbering.

Mining Methods: The earliest work was largely a gophering operation, carried on at a time when uncertain markets necessitated sporadic mining. In later years production has been obtained through inclined shafts spaced at intervals of approximately 1200 ft along the ore body. The deepest of these has been extended 350 ft along a 52° slope. From these and appended crosscuts, drifts have been driven along the deposit in both directions. Most of the talc has been removed by overhand stoping. Talcs from the Western mine have been used for a variety of purposes in the past. Almost all of the current output is being absorbed by the ceramic industry, principally in the manufacture of wall tile.

Other Active Properties in the Death Valley Area: Other active properties in the Death Valley talc province include the Excelsior and Smith mines on the east and west flanks, respectively, of the Kingston Range; the closely grouped Monarch, Pleasan-

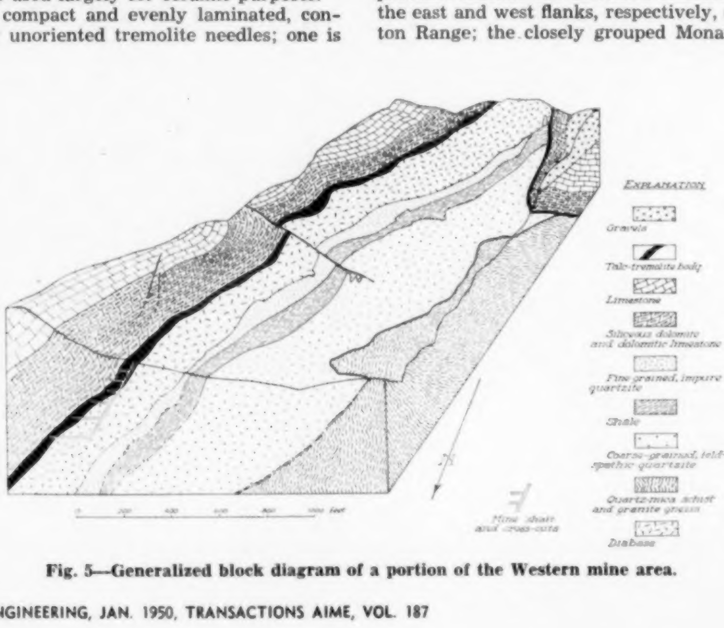

Fig. 5—Generalized block diagram of a portion of the Western mine area.

ton, and Ibex mines near Ibex Springs at the southern end of the Ibex Hills; the Superior and White Cap mines near Saratoga Springs at the southernmost tip of Death Valley; the Warm Springs mine in Warm Springs Canyon on the east flank of the southern Panamint Range; and the Western Atlas mine near the base of the north flank of the Avawatz Range. At each of these the general rock units exposed at the Western mine are duplicated. At the Smith mine area, however, a rhyolitic volcanic rock also is exposed. It forms extensive intrusive masses in the sediments, diabase, and talc bodies. The commercial talc bodies at the Superior and White Cap mines lie beneath, instead of above, the diabase sill.

The talc now being mined at Warm Springs (fig. 7) is in the lowermost of three parallel talcose zones that are separated by silica-rich calcareous layers. The deposits at this locality, though poorly exposed and but recently developed, may well be among the largest in the state. The talc bodies dip gently and are mined by closely-spaced parallel adits driven from a canyon wall. The adits are joined by low-angle raises that are progressively enlarged to overhand stopes. Talc is removed by tramming and practically no timbering is required. This mining procedure is the simplest of any talc mine currently operating in the eastern belt. Development thus far has been confined to a relatively small portion of the talcose zone, which is approximately two miles long.

Despite broad similarities, the deposits of the Death Valley province do differ markedly in mineralogic detail. The compact, tremolitic talc of the Western mine, for example, is not a widespread rock type. In many deposits even a talc-tremolite aggregate is uncommon or absent altogether, and fibrous or micaceous forms of the mineral talc predominate. The fibrous and micaceous talcs are used with tremolitic talcs in ceramic blends, or are marketed unblended for consumption in the paint, rubber, textile, and paper industries.

Talc City Mine: *Location and Production History:* The Talc City mine, near the southern end of the Inyo Range, is 13 miles southeast of Keeler, in Inyo County. This mine, which was first operated in 1915, has yielded more than 200,000 tons of talc, the largest total of any California property. The product, like that from several other mines in the Inyo province, is unusually pure and was considered a critical material during World War II. The area drew the attention of the U. S. Geological Survey in 1942, when a detailed study was made under the direction of Dr. B. M. Page. The following description is based in large part upon data kindly supplied by Dr. Page[4].

Geology: The talc bodies of the Talc City mine area are contained in an irregular mass of dolomite, many hundreds of feet in maximum dimension. Paleozoic limestone, from which the dolomite appears to have been developed by hydrothermal alteration, both surrounds this mass and is included in it as residual "islands." Irregular bodies of a quartzite-like rock are also included in the dolomite, but their origin is obscure. The largest of these lie along the eastern borders of the limestone "islands," but some are themselves individual islands in the dolomite.

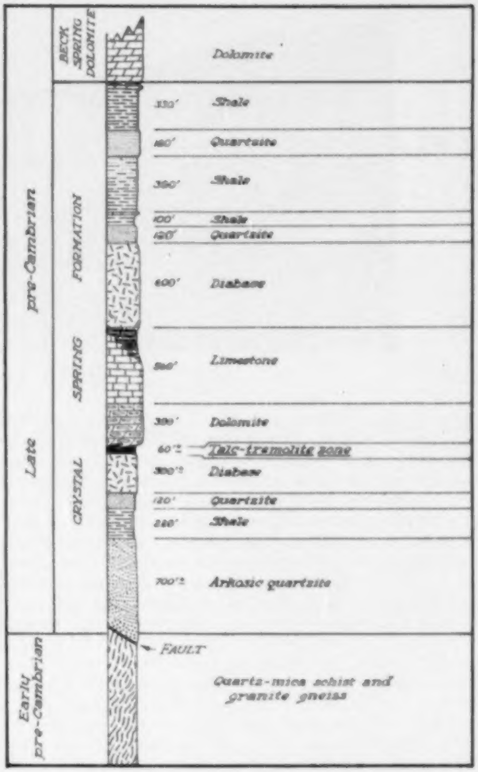

Fig. 6—Columnar section of the pre-Cambrian rocks exposed in the Western mine area.

The principal talc bodies characteristically occur along limestone-dolomite contacts that form the eastern borders of "islands." Others lie completely within dolomite. Much of the talc alteration appears to have been guided by shear zones. Nearly all of the talc at the Talc City mine was formed at the expense of dolomite, though at nearby mines and elsewhere in the Inyo province silica-rock has been extensively altered to talc. Four major ore bodies are exposed at Talc City; all are elongate and somewhat lenticular, but are irregular in detail. The two with the largest surface exposures are slightly more than 500 ft long and 50 ft in maximum width.

Mining Methods: Early operations were based on glory-hole mining, but an underground caving method was later employed. More recently the ore has been removed from overhand stopes that are supported by timbers where necessary. Systematic exploration since 1942 has outlined a downward and lateral extension of the largest talc body. Consequently the mine's proven reserves are now greater than at any time in its history.

Uses: Early production was used largely in the manufacture of paint, soap, paper, and cosmetics.

Fig. 7—A portion of the Warm Springs Canyon talc zone. Talc bodies lie within siliceous limestone near the upper contact of a diabase sill.

The blocky nature of the talc which generally distinguishes the "steatite" variety made it suitable for the manufacture of carved electrical insulator bodies. As the demand for such bodies grew, particularly for use in high-frequency and ultra-high-frequency electrical equipment, manufacturing methods were developed which employed extrusion or molding. Thereafter "steatite" did not necessarily imply a carveable material, and the term, as used in the ceramic industry, has consequently come to mean any talc of sufficient purity (CaO and Fe_2O_3 contents each less than 1.5 pct) that is adaptable to the currently-used techniques of insulator manufacture. It has been found, however, that talcs that grind to equant grains are more easily molded or extruded than talcs that grind to fibrous or micaceous grains. Moreover, the blocky "steatite," from which insulators previously had been carved, has been found to have equant grains in both natural and powdered form. The term "steatite," therefore, has not been applied generally to fibrous or micaceous talc even though they are sufficiently pure.

Early in World War II the national importance of the Inyo talc province as the principal domestic source of high-quality steatite became apparent. Heavy demands were placed on mines producing talcs of proven grade, and stringent government restrictions were placed on the use of such talc for any purpose other than the manufacture of electrical insulators. The Talc City mine proved to be the major source, but the White Mountain mine, on the southeast flank of the Inyo Range, shared a large portion of the wartime burden.

Other Talc Deposits of the Inyo Range Area: Talcs of steatite grade also occur at a number of smaller deposits in the Talc City area. These include the Alliance, Irish, Frisco, East End, Victory, Viking, Trinity, and White Swan mines, most of which were operated during World War II. Other deposits on the east and west flanks of the Inyo Range also contain steatite.

Noteworthy among the talc deposits of the Inyo province is the White Eagle[5], on the east flank of the Inyo Range above northern Saline Valley. Here a large, irregular talc body has formed principally through alteration of quartz monzonite.

Quartzite and dolomitic limestone of Paleozoic age border portions of the deposit and, near the contact, have themselves been altered to talc. The main talc body, however, is bordered by quartz monzonite and contains many quartz monzonitic residua. In many places the quartz monzonite-talc transition is complete within a few inches and is characterized by a decomposition of hornblende and biotite, and the replacement of feldspar and quartz by talc.

In recent years the Talc City and White Mountain mines have been the only ones continuously operated. The Lane and Nikolous mine in Eureka Valley, however, has been a substantial producer, and numerous other mines have been operated intermittently. With the end of World War II, restrictions on the use of high-quality steatite were lifted, and the material is now being employed in the manufacture of refractories, paint, paper and cosmetics, in addition to the manufacture of insulators.

Acknowledgments

The current studies of California's talc resources have proceeded at the instigation and under the helpful guidance of Dr. Olaf P. Jenkins, Chief of the California Division of Mines. Drs. Ian Campbell, R. H. Jahns and A. E. J. Engel of the California Institute of Technology also have been particularly helpful, both in offering suggestions in the field and in critical reviews of this manuscript. Valuable field assistance was rendered by Robert S. Orr, who voluntarily aided field studies at the Talc City mine, and by William E. Ver Planck and Mort D. Turner of the California Division of Mines.

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aime NEWS

Over Seventy Technical Sessions, Plus Excellent Social Fare, for the 1950 AIME Annual Meeting at the Hotel Statler, New York City, Feb. 12 to 16

YOU had better don your spectacles to glance over the business, technical, social, and Woman's Auxiliary programs for the 170th AIME Meeting to be held at the Hotel Statler, New York City, Feb. 12 to 16, because if you do, you'll know that you can't afford to miss it. The facts —all but the last minute surprises—are here so get a pencil and outline your schedule for the meeting.

The Council of Section Delegates will be the first to gather; that will be Saturday, Feb. 11, at 10 a.m., so as not to interfere with technical sessions. The old Board of Directors meets Sunday at the Statler at 10 a.m. with incoming Directors and Section Delegates invited as guests. The meeting will adjourn about 1 p.m. for lunch but will continue in the afternoon if it is necessary to clean up business.

The Annual Business Meeting, to which every member is invited to hear and discuss reports for the year, will be at 4 p.m. Monday. Immediately thereafter, the new Board will meet to elect a Treasurer, Secretary, and Executive and Finance Committees for the coming year. This will be in executive session, but may be followed by open session if desired.

This year the Mining, Geology, and Geophysics Division are holding a "cleanup session" at 9 a.m. Thursday for the first time. This is a multiple-purpose meeting. Unfinished discussion of papers or new subjects of technical nature may be introduced, but also the session will be a clearing house for ideas, gripes, or discussion of the operation of the Division.

Officers of the Mining, Geology, and Geophysics; Coal; Minerals Beneficiation; and Industrial Minerals Divisions will convene for the first time at 4:30 p.m. on Tuesday to discuss the establishment of a Branch Council and the possible appointment of a Branch Secretary.

Mineral Industry Education

Sunday Afternoon and Evening

Place: Columbia University Men's Faculty Club. Theme: Difficulties with Mineral Education. Curtis L. Wilson, Chairman.

A professor's idea of what constitutes a proper education and what it should qualify a man to do:

Mining Engineering. A. C. Callen, Lehigh University.

Geology. J. T. Singewald, Jr., Johns Hopkins University.

Petroleum Engineering. H. H. Power, University of Texas.

Mineral Preparation. A. F. Taggart, Columbia University.

Metallurgical Engineering will also be discussed.

Buffet Supper

A research director's idea of what constitutes a proper education and what it should qualify a man to do:

Mining Engineering. E. D. Gardner, U. S. Bureau of Mines.

Geology. H. M. Bannerman, U. S. G. S.

Petroleum Engineering. J. A. Putnam, University of California.

Mineral Beneficiation. F. X. Tartaron, Jones & Laughlin Steel Co.

Metallurgical Engineering will also be discussed.

Monday Morning

Coal Mining Curricula Re-established at the Colorado School of Mines. A. M. Keenan, Colorado School of Mines.

Fuel Economics Education. J. J. Schanz, Jr., Pennsylvania State College.

College Enrollment Statistics. W. B. Plank, Lafayette College.

Graduate Study and Research in Schools of the Mineral Industry. D. S. Eppelsheimer, Missouri School of Mines.

Tuesday Noon

MIED Luncheon

Mineral Economics

Monday Afternoon

Foreign Enterprise and the American Mineral Industry. Check the final program at the meeting for the names of unannounced speakers and date and

time of session. Subject of talks listed may not be exact title of paper.

The pattern of ECA. Charles H. Burgess, ECA, Washington, D. C.

Fuels in world recovery. George A. Lamb, Pittsburgh Consolidated Coal Co.

Iranian developments. John R. Lotz, Stone and Webster.

American government and American mining abroad. A national legislator will speak on this subject.

Wednesday Afternoon

Incentives for American Mining?

Incentives for the mining industry. Speaker to be announced.

The small mining enterprise today. Speaker to be announced.

Incentives in the petroleum industry. Hugh A. Stewart, director of the oil and gas division, U. S. Department of Interior.

Taxation policies and the mineral industry. Granville S. Borden, mining attorney, San Francisco.

Mining Geology

Monday Morning and Afternoon

Joint sessions with the geophysicists

Geophysics Applied to Engineering. Mr. Sharon and Arthur B. Cleaves, Washington University.

Will Airborne Methods Usher in a New Era in Mineral Prospecting? Hans Lundberg, geophysicist, Toronto.

Notes on Geothermics. C. E. Van Orstrand, geophysicist, Manito, Ill.

Application of Geophysics to Mineral Deposits. Harrison Schmitt, consulting engineer, Silver City, N. M.

Tuesday Morning

Joint session with the Society of Economic Geologists

Geology of the Aguilar Lead-zinc Mine, Argentina. Frank N. Spencer, Jr., Cia. Minera Aguilar.

Structural Control of Some Gold Base Metal Veins in Eastern Grant County, Oregon. Rhesa M. Allen, Jr., Virginia Polytechnic Institute.

Geology of the Agua Fria Mining District, Honduras, C. A. J. Barreto.

Nevadan, Laramide Tertiary Upheaval and Related Ore Deposits. Edward Wisser, Berkeley, Calif.

Classification of Ore Deposits. Harrison Schmitt.

Wednesday Morning

Joint session with Mining Methods, see Mining Methods program under Wednesday morning for more papers.

Ores and Mining in the Itabira Iron District, Brazil. John Van N. Dorr IV, The Dorr Co.; and Gilbert Whitehead, Cia. Valedo Rio Doce, S. A.

Application of geology to mining operations symposium.

Geological Mapping of Stopes and Its Application to Mining. T. E. Gillingham, Bunker Hill & Sullivan; and F. H. Howell, Federal Mining & Smelting Co.

Geology Applied to Mining in the Picher Mining Field. Joseph P. Lyden, geologist, Joplin, Mo.

The Function of a Mine Geological Department. J. D. Bateman, Giant Yellowknife Gold Mines.

Relationship of Geology to Mining Methods. George B. Clark, University of Illinois.

Wednesday Noon

Mining Geology Luncheon

Wednesday Afternoon

Joint session with the Industrial Minerals Division

A Sound Basis for Estimating Grade in Pegmatites. L. R. Page and James Norton, U. S. Geological Survey, Denver Branch.

Clay Resources of the Northwestern States. I. G. Sohn, U. S. Geological Survey, Washington, D. C.

Mineral Deposits in Montana Pre-Beltian Rocks. E. W. Heinrich and E. S. Perry, University of Michigan.

Chromite and Associated Mineral Occurrences. Ferid Kromer, Bastas Türk Maadin Ltd.

A Summary of Occurrences of Fluorspar in Spain. J. L. Gillson, E. I. du Pont de Nemours.

Alumina Possibilities of the Columbia River Basin. I. G. Sohn.

Fluorspar Deposits of Mexico. R. M. Grogan, Illinois Geological Survey.

Thursday Morning

Mining Division Cleanup Session Two more round table forums may be organized on the following subjects: Why has geophysics not been applied more intensively to mineral deposits in the past and what should be done about it in the future? The origin of iron deposits of the Lake Superior district.

Note: An innovation on the geology program is an all-Division session, including the mining methods people and the geophysicists, to clean up odds and ends arising during the meeting and to make plans for the future. This will be called the "Division Cleanup Session" and is scheduled for Thursday morning. It is a little more than that as it is also an open-house session for ideas on the operation of the Division.

Geophysics

Monday Morning and Afternoon

Joint sessions with Mining Geology group, see program under Mining Geology, Monday morning and afternoon.

Thursday Morning

Mining Division Cleanup Session. See "Note" under Mining Geology program Thursday morning.

Mining Methods

Monday Afternoon

Mine and Surface Maps. Neil O'Donnell, Idaho Maryland Mines Corp.

Diesel Truck Haulage Through Incline Adit from Mine Stopes to Mill. V. C. Allen, Tri-State Zinc Inc.

Sinking a 1400-Ft. Circular Production Shaft by the Tennessee Copper Co. L. Weaver, Tennessee Copper Co.

Tuesday Morning

An Arrangement for Pumping Acid Mine Water at a Tri-State

Mine. H. A. Krueger, St. Louis Smelting & Refining Co.

Millisecond Split Delay Detonators. D. M. MacFarland, Atlas Powder Co.

Failure of a Mine Opening as Observed in a Model. Bernard York and W. E. Bush, University of California.

Review of Progress in the Caving of Asbestos Ore. Gerald Sherman, Consulting Mining Engineer.

Tuesday Afternoon

Joint session with Industrial Minerals Division, see Industrial Minerals program under Tuesday afternoon.

Wednesday Morning

Joint session with Mining Geology, see Mining Geology program under Wednesday morning for more papers.

Block Caving at the Cleveland-Cliff Iron Company Mines on the Marquette Range. D. K. Campbell and Hugo H. Korpinen, the Cleveland-Cliffs Iron Co.

Classification of Block Caving. F. S. McNicholas, consulting mining engineer, Denver, Colo.

Wednesday Noon

Mining Methods Luncheon

Thursday Morning

Mining Division Cleanup Session, see "Note" under Mining Geology program Thursday morning.

Minerals Beneficiation

Monday Morning

Flotation

Flotation Test on a Korean Scheelite Ore. Will Mitchell, Allis-Chalmers Mfg. Co., C. L. Sollenberger, and T. G. Kirkland.

Adsorption of Radioactive Dodecylamine on Quartz. A. M. Gaudin and F. William Bloecher, Jr., MIT.

Radiotracer Studies on the Interaction of Dithiophosphate with Galena. G. L. Simard, J. Chupak, and D. J. Salley.

Use of an Induced Nuclear Reaction for the Concentration of Beryl. A. M. Gaudin, John Dasher, James H. Pannell, and Wilfred L. Freyberger.

Monday Afternoon

Crushing and Grinding

Progress Report, Tennessee Copper Co. J. F. Myers and F. M. Lewis of that company.

Hydroscillator as a Machine. W. C. Weber, The Dorr Co.

Grindability Tests. E. J. Roberts, consulting mining engineer, Los Angeles.

Grinding Mills as Conditioners in Sulphide Flotation. C. G. McLachlan, Noranda Mines, Ltd.

Tuesday Morning and Afternoon

Symposium on mill management

Functioning Organizational Charts and Their Application to Mill Management.

Labor Relations and Mill Management.

Mill Management and Technical Problems.

Mill Management Relationship with Corporate and Company Executives (Problems of integration of mill operation into over-all unit).

Mill Management and the Small Milling Companies (problems peculiar to small mill management).

Tuesday Noon

Division Luncheon, H. R. Huston, guest speaker

Wednesday Morning

Scotch breakfast, 7 a.m.

Joint session with Industrial Minerals Division on Flotation, 9 a.m.

Concentration Operations of the Yunnan Consolidated Tin Corp., Kochiu, Yunnan, China. T. T. Ni and Shiou-chuan Sun of that company.

Concentrating Ilmenite at Piney River, Va. C. J. Kirkland and C. E. Craven, American Cyanamid Co.

Pilot Plant Investigation of Concentration of Blackbird Cobalt.

Ore by Roast-flotation Process. S. R. Zimmerley and S. F. Ravitz, U. S. Bureau of Mines, Salt Lake City.

New Methods of Recovery of Flake Mica. R. B. Adair, North Carolina State College.

Concentration of Feldspar. J. A. Barr, Jr., Armour & Co.

Wednesday Afternoon

Flotation

Measurement of Equilibrium Forces Between an Air Bubble and an Attached Solid in Water. T. M. Morris, Missouri School of Mines and Metallurgy.

Effect of $BaCl_2$ and Other Activators on Soap Flotation of Quartz. R. Schuhmann, Jr., and Brahm Prakash, MIT.

Effects of Activators and Alizarin Dyes on Soap Flotation. R. Schuhmann, Jr., and Brahm Prakash.

Trends in Practices and Costs of Sink-float Conditions of Mineral Beneficiation. H. F. Lynn, Southwestern Engineering Co.

Wednesday Afternoon

Cyanidation and Operating Controls

Continuous Counter Current Decantation Calculations. T. B. Counselman, The Dorr Co.

Chemistry of Cyanidation. N. Hedley and H. Tabachnick.

The Action of Sulphide Iron and of Metal Compounds on the Dissolution of Gold in Cyanide Solutions. G. L. Putnam.

Automatic Control of Grinding in Castle Dome Copper Co. Concentrator. R. L. Mountjoy and T. D. Henderson.

Controlling Long Distance Sand Pumping. W. B. Stephenson.

Thursday Morning

Materials Handling

A Novel Pump for Coarse Gravel and Rock. George T. Bator, Colorado School of Mines.

Design Considerations for Large Conveyor Belts. W. Snavely.

Conveyor Belt Care and Maintenance. J. R. Thompson.

Extending Our Iron Ore Reserves Through a New Approach to the Problem of Taconite Utilization. John J. Howard, Philadelphia, Pa.

Thursday Afternoon

Cleanup Session

Industrial Minerals

Monday Afternoon

Economics of Some Industrial Minerals

The Economics of Industrial Carbon. C. A. Stokes, Godfrey L. Cabot Co.

Limestone—Demand and Supply. K. K. Landes, University of Michigan.

The A, B, C, and D of Marble. Romer Shawhan, Marble Institute of America, Inc.

Economic Import of Flotation to the Development of Industrial Minerals. J. A. Barr, Jr., Armour & Co.

Strategic Nonmetallic Minerals. LeRoy M. Otis.

Executive Committee meeting, 5:15 p.m.

Tuesday Morning

Vermiculite Production in South Carolina. J. A. Kelley, southern division, Zonolite Co.

Synthetic Corundum. R. C. Cole, Munitions Board, Washington, D. C.

Progress in Industrial Minerals of North Carolina. J. L. Stuckey, Department of Conservation and Development, Raleigh, N. C.

Limestones in Western North Carolina. Willard Berry, Duke University.

The Nature, Value, and Age Relations of Kansas Industrial Mineral Products. Earl Nixon, Kansas Geological Survey.

The Recent Calaveras Cement Co. Dust Suit. W. W. Mein, Jr., Calaveras Cement Co.

Tuesday Noon

Division Luncheon

Tuesday Afternoon

Joint Session with Mining Methods

Granite Quarrying and Technology. F. S. Eaton, The Research and Design Institute, Inc.

Basic Research on Physical Properties of Rocks as Applied to Drilling Problems. W. B. Mather, Southwest Research Institute.

Wednesday Morning

Joint session with Minerals Beneficiation Division, see MBD program under Wednesday morning. Paralleling joint session is one on Sand.

The Sands of New Jersey. J. H. C. Martens, Rutgers University.

The Foundry Sands of Ohio. C. H. Bowen, Ohio State University Experiment Station.

Production of Graded Glass Sand by Grinding and Classification. M. M. Fine, U. S. Bureau of Mines.

Modern Beneficiation in Grading up Glass Sand. Paul Tyler, consultant, Kensington, Md.

Glass Sand and Sand Beneficiation.

Wednesday Afternoon

Joint session with Mining Geology committee, see Mining Geology program under Wednesday afternoon.

Thursday Morning

Clay and Fillers

Florida Kaolins and Modern Methods of Preparation for Market. George Lane, Edgar Plastic Kaolin Co.

Control of Particle Size in Fillers. L. T. Work, Metal Thermil Corp.

Fullers Earth. H. L. King and A. C. Amero, Johns-Manville Corp.

The Utilization of Natural Brines from California Dry Lakes for the Manufacture of Soda Ash by Carbonation. F. H. May and M. L. Leonardi, American Potash and Chemical Co.

Coal

Monday Morning

Session on Coal Mining

Monday Afternoon

Session on Safety

Executive Committee meeting 5 p.m.

Tuesday Morning

Session I on Fine Coal Cleaning

Tuesday Noon

Division Luncheon

Tuesday Afternoon

Session II on Fine Coal Cleaning

Wednesday Morning

Session on Coal Preparation

Wednesday Afternoon

Session: American Men and Machines in Foreign Coal Mining

Extractive Metallurgy

Monday Morning

(Primary and Secondary)

Extractive Metallurgy of Aluminum. R. S. Sherwin, Reynolds Metals Co.

Metallurgy of Secondary Aluminum and Magnesium Alloys. Walter Bonsack, Apex Smelting Co.

Production of Aluminum from Kalunite Alumina. Arthur Fleischer, Nickel Cadmium Battery Corp. and Julian Glasser, Armour Research Foundation.

Amex Modification of the Kalunite Process for the Production of Alumina. Arthur Fleischer.

Aluminum Recovers Itself. Stanley H. Brown, Permanente Metals Corp., Aluminum Alloys Division.

Monday Afternoon

Titanium, Zirconium, Manganese

A Continuous Method of Producing Ductile Titanium. P. J. Maddex and L. W. Eastwood, Battelle Memorial Institute.

The Electrical Resistivity of Titanium Slags. James L. Wyatt, Titanium Division, National Lead Co.

Recent Practice at the Boulder City Titanium Plant. F. S. Wartman, H. C. Fuller, and D. H. Baker, Jr., U. S. Bureau of Mines.

Pilot Plant Production of Malleable Zirconium. W. J. Kroll, W. W. Stephens, and H. I. Holmes, U. S. Bureau of Mines.

Metallic Manganese Metallurgy in Japan. P. B. Dettmer, Oakland, Calif.

Tuesday Morning

Copper

Core Type Induction Furnaces of Large Capacity for Melting Nonferrous Metals. Manuel Tama, Ajax Engineering Co.

Treatment of Electrolytic Copper Refinery Slimes. J. H. Schloen and E. M. Elkin, Canadian Copper Refiners, Ltd.

History of the Development of Mechanical Tuyere Punching at the McGill Smelter. Leonard Larson, Kennecott Copper Corp.

Review and Preview of the Physical Chemistry of Copper Smelting. R. Schuhmann, Jr., M. I. T.

Tuesday Afternoon

Zinc

Recovery of Zinc Dithionate Sulphur-dioxide Leaching Process.

S. F. Ravitz and A. E. Back, Bureau of Mines.

The Calbeck Process for Refining Zinc Oxide. John H. Calbeck, William T. Maidens, and Oscar J. Hassel, American Zinc Oxide Co.

Low Pressure Distillation of Zinc from Aluminum-zinc Alloy. M. J. Spendlove and H. W. St. Clair, Bureau of Mines. (**Jl. of Metals,** Sept.)

Refining of Zinc. Stanley Robson, Zinc Corporation, Ltd.

Brief History of Filtering Practice at Risdon. V. A. Corstorphan, Electrolytic Zinc Co. of Australia.

Design and Operation of a Counter-Current Gas Scrubbing System. F. H. C. Kelley, Electrolytic Zinc Co. of Australia.

Tuesday Evening

Metals Branch Dinner

Wednesday Morning and Afternoon

Round Table Symposium on Fume and Dust Collection

Fume and Dust Problem in Industry. Harry V. Welch, Western Precipitation Co. (**Jl. of Metals,** Dec.)

Hygiene Program Control of Dust and Fume in a Smelting Industry. J. M. Abersold, American Smelting and Refining Co.

An Improved Automatic Smoke Sampler. J. J. Donoso, American Smelting and Refining Co.

Modern Baghouse Practice for the Recovery of Metallurgical Fumes. A. L. Labbe and J. J. Donoso, American Smelting and Refining Co.

Conditioning Dwight-Lloyd Gases to Increase Bag Life. R. E. Shinkoskey, American Smelting and Refining Co.

Wednesday Noon

Division Luncheon

Acid Conditioning of Metallurgical Smoke for Cottrell Precipitation. A. L. Labbe, American Smelting and Refining Co.

Treatment of Dwight-Lloyd Gases, Tooele Plant (Anaconda). B. L. Sackett, Anaconda Copper Mining Co.

How the Operation of a Cottrell Precipitator is Affected by the Resistivity of the Collected Material. Walter A. Schmidt, Wayne T. Sproull and Y. Nakada, Western Precipitation Co.

Ultra-sonic Precipitation. Harold Danser, Ultra-sonic Corp.

Extractive Metallurgy Division, General Meeting, 4:45 p.m.

Thursday Morning

Lead, Antimony

Relationship Between Electrical Conductivity and Composition of Molten Lead Silicate Slags. A. K. Schellinger and R. P. Olsen, Stanford University. (**Jl. of Metals,** Dec.)

Water Sealed Wind Boxes for Dwight-Lloyd Sintering Machines. E. McL. Tittmann and E. A. Hase, American Smelting and Refining Co.

Development of the Lead Blast Furnace at Port Pirie, South Australia. L. A. White, Broken Hill Associated Smelters.

Electrolytic Refining of Antimony Bullion. D. Schlain, J. D. Prater, and S. F. Ravitz, Bureau of Mines.

Thursday Afternoon

Cobalt—Nickel—Tin

Tin Metallurgy in Japan. P. B. Dettmer, Oakland, Calif.

Thermodynamic Relationships in Chlorine Metallurgy. Herbert H. Kellogg, Columbia University.

Fundamental and Practical Factors in Ammonia Leaching of Nickel and Cobalt Ores. M. H. Caron, Delft, Netherlands. (**Jl. of Metals,** Jan.)

Separation of Nickel and Cobalt. M. H. Caron. (**Jl. of Metals,** Jan.)

Production of Cobalt Oxide, Cobalt Sulphate and Electrolytic Cobalt. Alan S. Gill, Electrolytic Zinc Co. of Australia.

Petroleum

The Petroleum Branch will hold four or five sessions, starting Monday afternoon and ending on Wednesday. They will be devoted variously to a seminar on economics, production technology, and technical personnel problems; production (statistics), foreign and domestic; technical papers; and an open meeting of the Executive Committee. The annual Branch dinner, to which the ladies are invited, will be held in the Salle Moderne, at the Statler on Tuesday evening.

Social Events

Welcoming Luncheon, Monday, Feb. 13, at 12:15 p.m. The speaker will be Dwight D. Eisenhower, president, Columbia University. Tickets $4 each. No advance reservations for tables will be made. Favors will be distributed to those attending.

Dinner-Smoker, Monday, 7 p.m. A splendid stag program has been arranged. Tickets $7.50. Souvenirs.

Columbia School of Mines, Alumni Reunion Dinner, Tuesday, Feb. 14, at 6 p.m.

Missouri School of Mines, Alumni Reunion Dinner, Tuesday, 6 p.m.

Mining and Metallurgical Society of America, Tuesday, Feb. 14, 12:15 p.m. Luncheon.

Informal Dance, Tuesday, 10 p.m. Refreshments at midnight. Tickets $2.50. For your added pleasure, square dancing with a professional caller.

Scotch Breakfast, Wednesday, 7 a.m. Sponsored by the Minerals Beneficiation Division, this affair is strictly for real engineers. There will be plenty of Scotch, two pipers, and a sleight-of-hand artist to dispel morning-after gloom. Get your tickets at the registration desk, for $5; better buy them early as there are only 150 of them.

President's Reception and Banquet, Wednesday, 7 p.m. Followed by presentation of awards and honors, the President's Reception, and then dancing until 1 a.m. Dress is optional, tickets $10 each. Tables accommodate ten persons. Seating list closed after 5 p.m. Feb. 14.

Ladies' Program—Visit to the Metropolitan Museum of Art on Monday afternoon. Tickets have been secured for a Monday evening theatre party. Tickets available for Touch and Go, Where's Charlie, Kiss Me Kate, and That Lady—all first-rate shows. A few ducats for the Metropolitan Opera are obtainable, as well as evening radio and TV shows. On Tuesday, a luncheon and fashion show will be held at the Park-Sheraton Hotel.

Woman's Auxiliary

Mrs. L. E. Young, Honorary Chairman;

Mrs. D. H. McLaughlin, Honorary Chairman;

Mrs. H. Y. Eagle, Chairman;

Mrs. T. T. Read and Mrs. S. H. Levison, Registration Chairmen;

Mrs. John P. Dyer, Membership Chairman;

Mrs. D. E. Park, Hospitality Chairman; and

Mrs. Loren Kemp, Information Chairman.

Monday Afternoon

View the Hapsburg Collection. Metropolitan Museum of Art. Mrs. H. W. Hardinge and Mrs. John C. Kinnear, Chairmen.

Visit to United Nations. Mrs. Loren Kemp and Mrs. C. H. Eichrodt, Chairmen.

Monday Evening

Radio and Television Tickets. Mrs. Howard Norsworthy, Chairman.

Theatre Tickets. Touch and Go, $4.80; Where's Charley?, $4.80; Kiss Me Kate, $4.80; The Rat Race, $4.20 and $4.80; Metropolitan Opera, $4.50. Chairman, Mrs. D. Moreno, 721 Field Ave., Plainfield, N. J. All shows are hits and no seats are above first mezzanine. It is necessary to indicate first, second, and third choice for theatre tickets.

Tuesday 9:30 a.m.

Annual Meeting

Tuesday 1:00 p.m.

Luncheon, Favors, Fashion Show by Gunther's. Cotillion Room, Hotel Pierre. Mrs. W. H. Aldridge, Luncheon Chairman; Mrs. Felix Wormser, Fashion Show Chairman.

Wednesday 10:00 a.m.

Round Table, Mrs. W. A. Scheuch, chairman.

There are approximately 78 technical sessions for which rooms have been assigned at the Statler. They are as follows:

Mining Methods, 4; Minerals Beneficiation, 9; Iron and Steel, 6; Extractive Metallurgy, 8; Institute of Metals Division, 16; Coal, 7; Petroleum, 5; Industrial Minerals, 7; Mining Geology, 7; Mineral Industry Education Division, 3; Geophysics, 3; Mineral Economics, 2. Besides these, there are the annual Howe Memorial and Institute of Metals Division lectures. Eleven special technical group luncheons are scheduled to date.

The Institute Research Committee will meet at 4 to 6 p.m., Tuesday.

The individual programs of Mining Branch groups presented below are more or less tentative. For more complete detail, see Mining Engineering for February.

Scholarship Committee of the Coal Division Reports

by Maurice D. Cooper, Chairman

At the present time, the Scholarship Fund of the Coal Division is being used by the Committee in making awards to three students: Lewis W. Howells, Jr., John C. Scott, Jr., and Joseph Rebeck.

Howells is starting his junior year at Lehigh University, where he was awarded a scholarship at the beginning of his second year. His scholastic record has been good; and he is an earnest student who has done hard manual labor in shaft-sinking operations during two summer vacations. It is probable that he will do well during the rest of his course and when he becomes regularly employed in the mining industry.

John Scott, a student at West Virginia University, made an outstanding record in high school in studies, athletics, and social activities, and was on the honor roll all four years. At the beginning of his course at the University, he was awarded a scholarship, and in June he completed his freshman year. Coming from a fine mining family in West Virginia, he has demonstrated his ability to do good work so that it may be expected that he will do well during the current college years.

Joseph Rebeck has just entered Colorado School of Mines to take the new coal mining option under Professor Albert M. Keenan. His father was a coal miner who died several years ago. A graduate of Adena High School in Adena, Ohio, where he ranked fifth in a class of 32 members, he was well recommended by his high school principal and officials of the Hanna Coal Co. His appointment is noteworthy because of the fact that he made the best record among all of the students who took the coal mining courses in the four high schools in Ohio providing such training. During summer work in the mines, he made a good impression upon his supervisors. Going to Colorado School of Mines was the culmination of several years of planning on his part, and he got a flying start by going on his own initiative to summer school preceding the opening of the fall term.

An applicant for a scholarship at Virginia Polytechnic Institute was recommended by his high school principal. He was interviewed by the professor of mining engineering and by the chairman of the scholarship committee, who endorsed the application which was in turn approved by vote of the members of the committee. When the letter of appointment was sent to the student, it was returned by his mother, who wrote that the father was a miner working three days a week and unable to supply the additional funds required. Therefore, the boy had already enlisted in the United States Navy.

The three scholarships granted by the Fund are undoubtedly given to worthy students. It is hoped that there may be more. In fact, it would be ideal if the income of the Fund were sufficient to provide for a scholarship in each of the colleges having an accredited course in mining engineering in the coal producing states. Looking at the whole field of education, it appears that the coal industry, in self defense or as a matter of self respect, must provide sufficient scholarships to insure a supply of well trained men to cope with the complex problems of operation in the years to come. Other industries are setting up scholarship programs to get good men. The coal industry must take an equally enlightened course so that it will get its share of the graduates in engineering. In this connection, it is a pleasure to report that many of the coal companies have scholarships which are awarded to the sons or daughters of employes, or to other qualified students. Let us hope that some

day each of the coal companies, with a production of a million tons or more per year, will have active scholarship plans.

Recently, a letter was sent to the members of the Coal Division asking for contributions to the Scholarship Fund. In response, gifts ranging from $1 to $50 and aggregating $353 were received up to Sept. 19. The average is over $14, an unexpectedly generous amount. The balance in the Fund is nearly $5800.

Fortunately, the Scholarship Committee is not governed by fixed rules. Its acts are not hardening into customs that may be disagreeable to future members of the committee. Usually, before a scholarship is awarded, the student must be properly endorsed by his high school principal, or employer, or both; his record in high school must be above average and indicate ability to pursue successfully a college course in coal mining engineering. He is expected to work in the mines during summer vacations. The members of the committee are given a written record of the candidate's qualifications, and they signify approval before the notice of appointment is mailed.

For the time being, the awards are given as follows: Freshman Year — $300, Sophomore Year — $350, Junior Year — $400, Senior Year—$400.

If the student merited reappointment in each succeeding year, he would receive a total of $1450 during a 4-year course of training.

The management of the Fund is in the capable hands of H. A. Maloney, Assistant Treasurer, AIME. He makes disbursements to students on written request of the Chairman of the committee. The only other expenses are trivial and are much more than offset by interest on the principal. The members of the Scholarship Committee, to all of whom the Chairman, M. D. Cooper, is grateful for prompt cooperation and constructive criticism are: A. C. Callen, L. I. Cothern, S. J. Craighead, Cadwallader Evans, Jr., Richard Maize, D. L. McElroy, R. H. Morris, E. R. Price, G. R. Spindler, J. W. Stewart, H. L. Walker.

Business Session
Covers Magazines, Officers, and Committees

WITH twenty Directors present, the Board again held a lengthy meeting on Nov. 16, gathering for an informal luncheon at the Engineers' Club at 12:30 and moving over to the Board room at Institute headquarters immediately thereafter for a business session that lasted until 5:20. President Young presided, as he has at all Board meetings during his term of office.

T. W. Lippert, Manager of Publications, announced certain changes in Mining Engineering and the Journal of Metals to be effective with the January issues. The volume number of each journal will hereafter correspond with the number of the Transactions volume containing the technical papers published in the journal during the year. Thus, instead of Vol 2 of ME and JM during 1950, the volume numbers will be 187 and 188 respectively. Also, the page numbers of each journal will hereafter be continuous from month to month throughout the year and will include all sections of the journal, thus avoiding the complex system that has obtained in 1949. Though these changes will result in gaps in the numbering of volumes, and in the paging of the Transactions volumes, they seem to be the best solution yet devised to objections offered by the Post Office and by readers to discontinuous paging in the monthly issues, and to difficulties in indexing.

Another change will be made which has been the subject of much controversy during the year: the editor of each of the three journals published by the AIME will select only those personals that he wishes to use, and the section of personals and obituaries common to all journals will be discontinued. All the items will be prepared at Institute headquarters as formerly but a selection will be made by each journal. This does not necessarily mean that each journal will limit its personals to items about the members of its own Branch, for it is expected that each editor will also carry the more important items about Institute members in other Branches as well. The reaction of readers is invited. To save space, the company connections and street addresses of applicants for membership are also being discontinued, and the possibility of complete elimination of the names of applicants is being studied.

Plans for increasing the advertising in all three journals were also announced. The Journal of Petroleum Technology will turn over advertising solicitation of new prospects in eleven Western states to the firm of McDonald-Thompson, of San Francisco and Los Angeles, and the Mining and Metals journals will appoint an advertising man with headquarters in Chicago, who may also be asked to solicit advertising in the Petroleum journal. Final approval for the appointment of the Chicago representative was voted at the meeting of the Executive and Finance Committees on Dec. 7.

In line with recommendations made in the Johnson Committee report two years ago, H. Newell Appleton was appointed in charge of internal business administration and office management at AIME headquarters. He will report to the Secretary, as before, but will have authority and responsibility for the conduct of business at Institute headquarters with the maximum efficiency. Mr. Appleton has served the AIME most effectively for 21 years in many capacities and is favorably known to many of those who have attended its conventions.

Further attention was given by the Board to a matter that had come up at the October meeting of the Finance Committee: what to do about the Engineering Societies Building. Costly repairs are imminent and the building is inadequate to meet the needs of its occupants. The feeling of the committee that has been studying the matter, as reported in person by William N. Carey, chairman, and secretary of the ASCE, is that serious consideration should be given to securing, or constructing, a new building and selling the present one. Many have also questioned whether or not the Founder Societies should continue to give the present substantial support to the Engineering Societies Library, and a home for this also enters into the picture. The United Engineering Trustees Real Estate Committee was encouraged by the Board to continue its study of the possibility of new quarters for the societies.

Official announcement was made of the election of the AIME officers presented by the Nominating Committee and published in the July issues of the journals. The ticket is headed by Donald H. McLaughlin

as President for 1950, with Andrew Fletcher and Robert W. Thomas as Vice-Presidents, and Harold Decker, Francis B. Foley, E. C. Meagher, C. V. Millikan, Gail F. Moulton, and Howard I. Young, Directors. Divisional Chairmen, and Directors ex officio for next year, are: Mining, Geology, and Geophysics, P. J. Shenon; Minerals Beneficiation, Grover J. Holt; Coal, Carroll F. Hardy; Industrial Minerals, Richard M. Foose; Institute of Metals, Maxwell Gensamer; Iron and Steel, H. K. Work; Extractive Metallurgy, Carleton C. Long; Petroleum, John E. Sherborne; Mineral Economics, Charles H. Behre Jr.; and Mineral Industry Education, Allison Butts.

Some discussion was devoted to a recommendation of the Coal Division that the initiation fee for Members and Associate Members be reduced from $20 to $10; this would reduce AIME income from that source by about $9000 a year, which might be offset by the enrollment of a larger number of new members. It was thought that greater publicity should be given to the fact that the present initiation fee could be paid in four annual installments of $5 each on request, about 17 percent of new members now taking advantage of this privilege. One suggestion was that no initiation fee be charged Junior Members when they must change their status to Associate or Member at age 33 but that the fee be charged in gradually increasing amounts, according to age, thereafter. It was decided to discuss the matter further at the Annual Meeting. How to handle the finances of Institute, Branch, and Divisional meetings, carrying out the idea that they should be self-supporting, also received attention by the Directors, with final decision to be made later.

The Mineral Industry Education Division was authorized to proceed with the implementation of its suggestion that a new major AIME award be given for notable contributions to mineral industry education. Approval was voted to the "Canons of Ethics for Engineers" adopted two years ago by the Engineers' Council for Professional Development; the AIME had previously not subscribed to any such code. An invitation was presented for the AIME to suggest a candidate for the award of the Kelvin Medal in 1950 by the Institution of Civil Engineers, of Great Britain. The medal is given for "distinguished service in the application of science to engineering." The Secretary will be glad to have AIME members suggest names for this honor.

Appointments to committees authorized by the Board include: Jack I. Laudermilk as vice-chairman of the Technical Publications Committee in lieu of Anthony Anable, resigned; Harold M. Bannerman on the Auxiliary Publications Committee of the Industrial Minerals Division, Oliver Bowles having declined; Francis B. Foley reappointed to represent AIME in the American Documentation Institute; James A. Barr to represent the AIME on the Committee on Deep Well Vertical Pumps, of the American Standards Association; A. Rodger Denison reappointed to represent AIME in the American Geological Institute; C. B. Sawyer to take the place of C. H. Mathewson, resigned, on the Council of the American Association for the Advancement of Science; Morris Muskat to represent AIME on the Committee on Fluid Permeation of the American Standards Association; and Manuel B. Llosa A. and A. Russell Merz to represent AIME at a meeting of the Peruvian Institute of Technical Valuations at Lima, Dec. 8-15.

Sherwin F. Kelly reported on a meeting that he had attended as an AIME delegate—that of the First Pan-American Engineering Congress at Rio de Janeiro, July 15-23. He urgently recommended that AIME lend its wholehearted support to the continued existence of PAEC (UPADI) and take an active interest in the work of that organization.

Directors present, besides President Young, were: Messrs. Alford, Benedict, Daveler, Elkins, Head, Kinzel, Kraft, McLaughlin, Meyerhoff, Millikan, Peirce, Phillips, Rhines, Schumacher, Sullivan, Swainson, Swift, Williams, and Wrather.

At a meeting of the Executive and Finance Committees on Dec. 7, with President Young and Messrs. McLaughlin, Schumacher, Daveler, Weed, and Fletcher present, various more or less routine and minor matters were disposed of. Approval was voted of a new Affiliated Student Society at the College of Engineering, New York University, with John P. Nielsen as Faculty Sponsor and Edmund M. Wise as Counselor.

The following prices were set on volumes in the Institute of Metals Symposium Series (superseding previous prices): Vol. 1, Nonferrous Melting Practice, and Vol. 3, Rod and Wire Production Practice, $2 to members and $3 to nonmembers; Vol. 2, Nonferrous Rolling Practice, $3 to members and $4.50 to nonmembers.

Attention Students! Attention Students!

A very special student function is being worked up for the Annual Meeting. It's so special we don't know what to call it. We're going to have engineers, maybe a geologist or two—not more than seven years out of school—speak to you on what life is like as an engineer the first few years out of college—no prepared speeches; strictly off the record; the straight dope which begins: "Don't quote me, but . . ." We're also getting in an expert who will tell you what to expect on a job interview; what to do and what not to do. Then a guy will tell you why you should belong to a professional society and how and what to get out of it. Oh, yes, there'll be beer, lots of it! This meeting will be held on Monday night, Feb. 13, at 8 p m at the Hotel Statler, meeting headquarters, in New York. You'll be able to ask all the questions you want, and after the formal program there'll be plenty of opportunity to talk things over with the speakers, meet the men from the other schools, and sing songs while polishing off the beer and pretzels. This will be the first meeting that you ever attended which will give you something to take home and think about, but starts off by tapping a keg of beer.

This meeting will be held at night so that you can attend technical sessions in the day time and get acquainted with the mining fraternity. A registration desk will be set up especially for students so you can get your name badge and programs. There will not be a registration charge for students, but 50 cents will be charged for your tickets to the student smoker.

If you are coming from out of town—and we expect students will be arriving by Stanley steamer, dog team, and pogo stick—drop a line to John V. Beall, AIME, 29 West 39th St., New York 18, N. Y., and he will try to arrange for reasonably priced accommodations at YMCAs and frat houses.

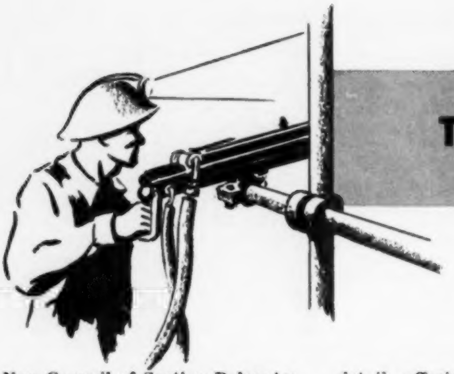
What Went on at Recent Local Section Meetings

SECTION	DATE	ATTENDANCE	SPEAKER, AFFILIATION, AND SUBJECT
Ajo Subsection	Nov. 10	25	S. Carpenter, Phelps Dodge Corp., on copper smelter metallurgy.
Arizona	Nov. 14	296	Annual meeting. L. E. Young, President, AIME.
Black Hills	Dec. 6	48	J. O. Harder, Homestake Mining Co., on meeting of G.S.A.
Boston	Nov. 7	47	L. E. Young, President, AIME, on coal mine mechanization; E. H. Robie, Secretary, AIME, on current Institute affairs.
Boston	Dec. 5	40	W. J. Cook, formerly with Patino Mines & Enterprises, on mining and labor problems in Bolivia.
Carlsbad Potash	Nov. 17	54	A. H. Zeilinger, Colorado Fuel & Iron Corp., on job training for production with safety.
Chicago	Nov. 2	98	J. P. Skinner, Linde Air Products Co., on sapphire.
Chicago	Dec. 7	89	W. C. Schroeder, Bureau of Mines, on synthetic liquid fuel research.
Cleveland	Nov. 17	60	W. M. Baldwin, Case Institute of Technology, on residual stresses in metals.
Columbia	Nov. 4	13	H. C. Cleavinger, Spokane *Chronicle*, on atomic bomb at Bikini.
Connecticut	Dec. 14	51	F. H. Wilson, American Brass Co., on intergranular parting of brass during anneals.
East Texas	Oct. 25	--	H. F. Dunlap, Atlantic Refining Co., on atomic energy.
El Paso Metals	Oct. 27	295	Banquet opening International Mining Days. J. H. Williams, lawyer, humorist, philosopher.
El Paso Metals	Nov. 9	50	H. F. Sparks, Southwestern Portland Cement Co., showed movie "Drama of Portland Cement."
El Paso Metals	Dec. 10	100	Christmas party—no speeches.
El Paso Metals	Dec. 14	29	R. Lindberg showed Joy Mfg. film on mechanized mining.
Gulf Coast	Oct. 18	102	E. E. Merkt, Jr., Gulf Oil Corp., on feasibility of water flooding in oil fields.
Gulf Coast	Nov. 15	133	J. B. Carsey, Humble Oil & Refining Co., on geology of Gulf Coast Area and Continental Shelf.
Gulf Coast	Dec. 13	100	W. C. Goins, Jr., Gulf Oil Corp., on lime mud systems.
Kansas	Oct. 5	70	G. C. Howard, Stanolind Oil & Gas Co., on hydrofrac process for increasing productivity of wells.
Kansas	Nov. 9	62	L. E. Young, President, AIME.
Kansas	Dec. 7	45	T. Orr, Kansas Independent Oil & Gas Assn., discussed Hoover Commission report.
Lehigh Valley	Nov. 17	29	Special luncheon for L. E. Young, President, AIME.
New York	Nov. 10	110	Ladies Night. C. Goodman, MIT, on nuclear energy.
New York	Dec. 7	64	L. E. Young, President, AIME.
North Pacific	Nov. 17	55	Joint meeting with student chapters of AIME and ACS at the Univ. of Washington.
North Pacific	Dec. 15	47	H. G. Poole, Univ. of Washington, on Mexican experiences in 1949.
Ohio Valley	Dec. 14	70	R. P. Goldthwait, Ohio State, on "Deep Freeze in Ohio."
Philadelphia	Oct. 27	31	E. M. Wise, International Nickel Co., on magnetic properties of nickel.
San Francisco	Nov. 9	96	Joint meeting with students at Stanford.
Southwestern N. Mexico	Nov. 8	80	H. Schmitt, consulting geologist, on geology in central New Mexico.
Southwest Texas	Nov. 16	150	J. W. Crutchfield, Crutchfield & Pruett, and E. Bowers, Southern Minerals Corp., on performance of the Lower Pawelek Reservoir.
Tri-State	Nov. 2	50	Movie on Paracutin, courtesy of C. Plumb.
Tri-State	Dec. 5	185	Joint meeting with Tri-State Zinc and Lead Ore Producers Assn.
Utah	Nov. 17	69	G. Hansen, Brigham Young Univ., on oil development in Utah.
Wyoming	Nov. 26	38	C. W. Tomlinson, President, AAPG, on "Lost Reserves."
Wyoming	Dec. 10	26	Dinner meeting; election of officers.

Among the Student Associates

The Howard Eckfeldt Society at **Lehigh** launched fall activities on Oct. 20 with a drive to interest more freshmen and sophomores in the Society. Speaker of the evening, H. F. Hebley, director of research for the Pittsburgh Coal Co., did a fine job of telling about the early days of coal mining in England. President Bob Smith called the Nov. 17 meeting to order at 7:45 p.m., glad to have professors and students from Lafayette and Mulenberg there to meet and hear the guest speaker, President of the **AIME**, L. E. Young. Dr. Young talked to the group about the place of student societies in Institute affairs and about the conditions and reception of mining graduates in the business world. Crucible Club membership at the **Mackay School of Mines** had reached the 100 mark by the Oct. 19 meeting. Faculty sponsor Jay A. Carpenter introduced Roy Swift, Mr. Larson, Mr. Martin and Mr. Classen, new faculty members, to the club; Bill Wood was elected treasurer. Jack Sullivan, John Cunningham, Bill Rankin, David Kinneberg, and Fred Muller told of their summer experiences in mining in California, Nevada, and Alaska. It was quite a meeting. The Student Chapter at the **Missouri School of Mines and Metallurgy** is really on the ball with its 153 members from last year and 54 new recruits. W. D. Humphreys is President; R. T. Jones, Vice-President; K. Del Porte, Secretary; R. Bullock, Treasurer; and D. R. Schooler and D. F. Walsh, mining and metallurgy Faculty Sponsors, respectively. At the chapter's first meeting on Sept. 21 every member turned out to hear Dean Wilson discuss the characteristics of an engineer. Mr. Robie visited the students on Oct. 1, giving them a broader view of the **AIME**, and conducted a question and answer period. M. M. Fine, of the Bureau of Mines, traced the development of heavy-media separation from its beginning to the modern ferrosilicon separation at the Oct. 26 meeting. His talk was of special interest to the senior mining students who had just returned from a trip where they viewed several heavy-media plants. Up in Durham, **University of New Hampshire** Student Chapter members made plans on Oct. 12 for coming meetings. In November they were to venture via the illustrated lecture platform to the Arc-

(Continued on page 140)



THE DRIFT OF THINGS

. . . as followed by EDWARD H. ROBIE

New Council of Section Delegates

Among other features of the forthcoming Annual Meeting will be the first gathering of the newly organized Council of Section Delegates. Thus is another of the recommendations of the Committee on Divisionalization and Publication Program (Hjalmar W. Johnson, chairman, with M. M. Leighton and Clayton G. Ball) coming to fruition. This Committee suggested "some form of representative assembly serving as a co-ordinating link between Sectional units of organization and the Central Administration. . . . The Council thus evolved should be made truly representative, with duly accredited delegates representative of the Local Sections, and possibly of the Divisions, possessing sufficient tenure of office to ensure continuity in its deliberations. . . . It should function in an advisory capacity only. . . . It would, in the first place, provide the electorate with orderly means of periodically informing the Directorate concerning membership views to a degree not now available, and in turn would provide the means by which the heavy responsibility and problems of the Central Administration could be better appreciated by the membership than is now often the case."

Following receipt of the Johnson Committee report, a "Committee on Democratization," consisting of Joseph L. Gillson, chairman, with E. A. Anderson and George B. Corless, was appointed to investigate the problem of democratization further and to activate the ideas of the Johnson Committee. It reported at the Annual Meeting in San Francisco last year, and one of its six points was the reorganization of the Section Delegates' group and replanning of its meetings. The Committee was asked to amplify its suggestion, and at the recent September meeting of the Board reported its recommendations in detail, offering provisional bylaws for the operation of the proposed Council. The forthcoming meeting will be organized and will operate under these bylaws.

Section Delegates' meetings are nothing new; they have long been on the program for our Annual Meetings. But heretofore the delegate has usually functioned as such for that meeting only; the agenda has been drawn up by the Secretary's office; the President of the Institute has presided; and the meetings have conflicted with technical sessions.

As envisaged by the Gillson committee, the principal duties of the new Council would be "(a) To receive proposals, complaints, and suggestions from individual members or Local Sections. It may appoint committees to investigate such and to formulate recommendations to present to the Board. (b) To keep the President of the Institute informed on affairs in the Local Sections. (c) To receive information about Institute affairs from the Board through the President of the Institute and to pass such information on to Local Sections."

Each delegate will be elected for two years, but to assure continuity of at least half of the group the two-year terms will be staggered; that is, half of the Local Sections are appointing a delegate to serve until Nov. 14, 1950, and half a delegate to serve until Nov. 14, 1951. To get the meeting started next February, the delegate from the Colorado Section, M. I. Signer, will be Chairman pro tem, and the delegate from the Permian Basin Section, Secretary pro tem. However, at the meeting, a Nominating Committee consisting of the delegates from the Boston, Gulf Coast, and Pennsylvania Anthracite Sections will report, offering a full slate of officers—Chairman, Vice-Chairman, Secretary, and four Executive Committeemen—who will, if elected, take office immediately.

The agenda for the meeting will be prepared by the delegates from the New York, Permian Basin, San Francisco, Upper Peninsula, and Colorado Sections.

Any Director or officer of the Institute may attend the Council's meetings as an observer, without vote, but only if invited.

Two meetings of the Council each year are authorized, but railroad expenses of the delegates will be paid only to the Annual Meeting of the Institute for the present. If a delegate cannot attend, an observer may take his place, or an observer may accompany a delegate, but an observer will in no case have a vote.

The Gillson committee suggested that "whenever possible, the meeting shall precede by a day or so, a scheduled Board meeting." The Council meeting therefore has been scheduled for 10 a.m., Saturday, Feb. 11, 1950, and it can continue through the afternoon and evening if need be. The Board will meet Sunday at 10 a.m. and all Section Delegates and observers are invited to be present and to participate in any discussion by the Directors of matters brought to the Board by the Delegates, or in any other topics in which they may be interested. The meeting of the Council will be entirely free of any conflicting sessions, and the meeting of the Board largely so. Time should be sufficient for full discussion of important matters.

Some skepticism has been expressed as to whether the proposed plan will be more satisfactory than the procedure that has been followed before. But the mechanics are available for a true and uninhibited expression of the sentiment of the rank and file. The success of the meeting is entirely in the hands of the delegates.

Branch Organization

Another of the important recommendations of the Johnson Committee was the organization of the Institute into three major professional groups—the Mining, Metals,

and Petroleum Branches. With the organization of the Mining, Geology, and Geophysics Division now recognized by the Board, the Divisional structure is complete and the Branch organization can now be consummated. The bylaws of the Institute provide definitely for a governing council for each branch, made up of at least six members, including one each from the Mineral Econonics and Mineral Industry Education Divisions, the other members being equally divided among the constituent Divisions. This means, in practice, that the Petroleum Branch council shall consist of six or more members, the Branch and the Division here being synonymous; the Metals Branch council must consist of at least eight members (there being three Divisions in this Branch); and the Mining Branch council shall consist of six members or more (there being four Divisions in this Branch).

The Petroleum Branch council has already been set up and is the same as the officers and executive committee of the Petroleum Division; in fact, the Division prefers to be known as the Petroleum Branch. Likewise, the Metals Branch council has been named, with A. A. Smith Jr. as Chairman, E. O. Kirkendall as Secretary, and an executive committee of six, including the Chairmen of its three constituent Divisions. It is hoped that the Mining Branch Council can be named at the Annual Meeting, at which time a meeting of the officers of its constituent Divisions is planned. Possibly for want of a directive, the Metals Branch council has so far been inactive but it is organized to act if it should be called upon.

So far, the responsibilities and duties of the Branch Councils have not been established, and this is a matter for early Board action. Certainly, general supervision over the Branch journals and the activities of component Divisions would seem to be within the province of the Branch councils. Fair appropriations from the national treasury for Divisional activities should be studied. One of the first responsibilities of the Mining Branch council, which will be discussed at the Annual Meeting, would presumably be to recommend to the Board whether or not a paid secretary should be employed, and if so, what his field of activity should be. The Johnson Committee suggested a field secretary for the Institute as a whole, and the Gilison committee specifically recommended a field secretary for the Mining Branch, with headquarters preferably in Salt Lake City.

The Noble Prize

Honors, awards, and prizes bestowed by the Institute are becoming so numerous that many of them are not as well known to the membership as they deserve to be. The Alfred Noble Prize is an example. It is not strictly an AIME prize, since it may be granted to the author of "a technical paper of particular merit" published by any of the Founder Societies or by the Western Society of Engineers. However, AIME members have frequently won it, as they did in both 1948 (John H. Hollomon) and 1949 (Robert L. Hoss). The cash prize is $350, and the expenses of the recipient are paid to the meeting at which the award is made. Competition for the prize is not severe, for it is limited to authors who have not passed their 31st birthday when the paper is accepted, and only a small proportion of the members of the societies in this category have reached the professional stature where they feel they can write an acceptable technical paper.

Here is an opportunity that should interest Junior Members, and those of our Members who are still in their twenties. The prize is decidedly worth while, as is the trip to the Annual Meeting, and the prestige of being the prizewinner may easily be worth considerably more than either, when it comes to looking for a job. All you have to do is to write a more outstanding paper than a dozen or so of your fellows. It's worth a try.

Continuing the Trip

In the November issue, the travels of the Secretary ended in El Paso on a rum note. This department got crowded out of the December issue, but the complaints thereby aroused from disappointed readers could have been counted by the Venus de Milo on the fingers of one hand.

From El Paso we drove to Silver City, N. Mex., where we found the small properties discouraged about the declining metal prices, but Kennecott's big open pit at Santa Rita was producing as usual, and a leaching project on some 125,000,000 tons of capping, containing about 0.35 pct. of copper, was underway, which should add a total of 400,000 tons to the country's copper production in the years to come. The ore for the concentrator runs a bit over 1 pct. in copper, about a tenth of which is oxidized. At the smelter at Hurley we found that the vibrating feeders on the reverberatories had been abandoned as they did not work satisfactorily on material containing around 9 pct. moisture.

Next stop, Inspiration, where we saw its open-pit operations for the first time, 15-yd. Dart trucks (24 tons) dumping 5,500 tons of ore daily direct to a 42-in. gyratory. An equal amount of waste has to be disposed of at present, but later on the waste should be but about 0.7 ton per ton of ore. At the leaching plant, capacity has had to be increased because of lower-grade ore. How was it done? By raising the walls of the leaching tanks 18 in., which increased their capacity by 12 pct., but involved a big job in rearranging piping. We were interested in the grizzly bars used in the belt discharge into the tanks to lessen segregation in the ore bed.

At Tucson we ran into a dads' and moms' day at the university, but T. G. Chapman had time for a good visit. Enrollment in the mining school there is at a peak and up a third over last year, with 216 undergraduates and 22 graduate students, though enrollment in the other engineering courses declined about 10 pct., to 660. Particularly close relationships with the mining companies are maintained, which helps in getting jobs in the summer and after graduation, and in securing scholarships.

Hollywood Sponsors Purity

Smog, which as everybody should know by this time, is a combination of smoke, fog, and any other troublesome matter that gets into the air of industrial communities when there is no wind, is a problem in many cities of the country. Metallurgical and chemical plants in the vicinity are viewed with extreme suspicion when smog persists, so that engineers concerned with dust and fume control are expected to contribute to the solution of the problem.

George E. Lynch, who has recently been working on the dustless incineration of some (but not all, of course) of the refuse of a movie company at Hollywood, as well as on the cleaning of openhearth gases in Pittsburgh, sends us a clipping about a new method to prevent smog in Los Angeles. Apparently almost everything has been tried, but still the September smog season last fall was the worst yet. The latest device is to name one of the Paramount girls—starlet we believe is the technical term—to be Miss Pure Air. She was to call on the mayors of Los Angeles County's 45 cities to seek their co-operation in National Smog Abatement Week. Her blond personality was supposed to spur the mayors to greater efforts, and her glamor was felt likely to be as effective as anything else in charming away the smog.

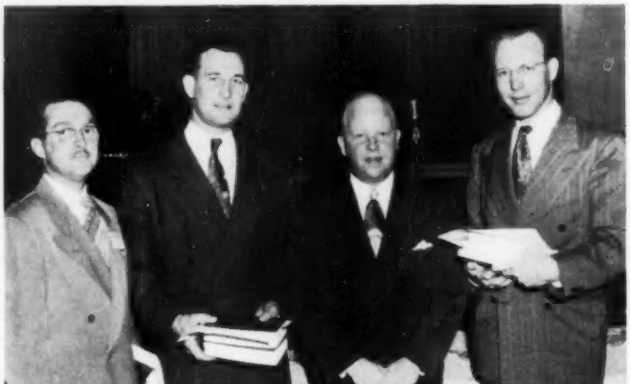
Among the Student Associates

(Continued from p. 137)

tic Circle, guided by D. H. Chapman, of their own geology department, learning what he saw there in 1937. To put the cart before the horse, Cooney Mining Club members at the **New Mexico School of Mines** closed the Sept. 23 meeting with twelve new members on the rolls. Faculty Sponsor Long had sold nonmembers on the advantages of AIME membership in his short opening talk. Then the club elected its officers: Thomas Parrott is President, Floyd J. Ballentine, Vice-President; James E. Kapteina, Secretary-Treasurer; and William W. Long, Faculty Sponsor. The Drill and Crucible Club at **South Dakota School of Mines** has great plans for this year, the 30th anniversary of the founding of the club. Officers who are putting these plans into action are: Guy Bennett, President; Russell Griffith, Vice-President; William S. Morrison, Secretary; and Larry Meyers, Treasurer. **Texas Western College** men—you used to know the school as Texas College of Mines but the hard-rock department lost its protest—held its election of officers at its first fall meeting. R. E. Lindberg holds the presidential reins, ably supported by Vice-President Robert M. Rayburn and Secretary-Treasurer Sam Christo. John F. Graham is Faculty Sponsor and E. McL. Tittman, Industrial Advisor. **VPI** celebrated home coming in October with all the usual social functions and the football game. The Burkhart Chapter of the AIME carried off first prize with its float in the float parade with pride and pleasure; after all, this was their first entry. Study the picture of the float and you'll see why it won. Mining men seem to be pretty keen fellows. Returning to earth, we find that Milton B. Harper is President of the Burkhart Student Chapter supported by Carl Shelton, Vice-President; Stonie Barker, Secretary; and Raymond Gibson, Treasurer. A ham dinner started things cooking at **University of Wisconsin** Mining and Metallurgy Club. Gathering in the metallurgical lab, the students found they had quite a crop of notables on hand; L. E. Young was there; so was M. O. Wither, G. J. Barker, E. R. Shorey, O. L. Kowalke, W. J. Rundle, P. C. Rosenthal, R. W. Heine, and E. F. Bean. The picture taken at the dinner will appear in next month's columns. That's all for now; more next month if the corresponding secretaries will correspond.

A float symbolizing the current situation in coal mining won first place and $60 for the Burkhart Student Chapter at VPI in the homecoming day parade. Complete with a "John L. Lewis," shaggy eyebrows and all, miners, who repeatedly "struck" during the line of march, a coal car with coal, and a Colonial character to represent George Washington U., home of the opposing football team whom Virginia Tech played at the homecoming game, the float was an exhibit of ingenuity and aptness of thought which pervaded the whole display.

On Nov. 17 L. E. Young, third from right, was made an honorary member of the John Markle Society, the second and only living honorary member the society has had. With him are W. B. Plank, Faculty Sponsor, F. J. Cinelli and F. B. Marion, J. H. Sherrard, President of the Society, and S. W. Tresouthick, Program Chairman.



At the All-Divisions luncheon of the Southern California section fall meeting on Oct. 21 three students received awards for their papers. In the usual order you are looking at T. R. Fahy, whose paper was Geology on the Sunland Area; C. W. Allen, author of Structure of the Northwest Puente Hills; R. L. Parsons, who made the awards; and Wm. Muehlberger, who wrote on the Mode of Emplacement of the Barre Granite, Vermont.

AIME Personals

David H. Ackerman left the geology department of the Jones & Laughlin Steel Corp. on Sept. 1 after being with that firm two years. He is taking geology courses at Columbia and doing part-time work for the Benson Iron Ore Corp., New York City.

W. S. Adams, formerly with the Torbrit Silver Mines at Alice Arm, B. C., can now be reached in care of the Saudi Arabian Mining Syndicate, Jeddah, Saudi Arabia.

H. Wm. Ahrenholz, Jr., has left the employ of the Bertha mineral division of the New Jersey Zinc Co. to become assistant professor of mining engineering at the School of Mines of West Virginia University.

Richard S. Bryson graduated from the Colorado School of Mines last September and took a job with the Geophoto Service of Denver as a geologist.

William H. Burgin is a geölogical engineer with the raw materials department of the Geneva Steel Co. in Provo, Utah.

J. Bruce Clemmer has been appointed regional director of the Bureau of Mines' Region VII, the Southeast, with headquarters at Tuscaloosa, Ala. With the Bureau since 1928, Mr. Clemmer is recognized as an authority on froth flotation for concentrating and separating both metallic and nonmetallic ores.

Earl Ferguson Cook is employed as a geologist with Geophoto Services of Denver. Formerly an instructor in geology at the University of Washington and at Stanford, he studied for a year at the University of Geneva, Switzerland, returning to the States last summer.

Theodore W. Becker, June graduate of the Michigan College of Mining and Technology, is working for the American Zinc, Lead and Smelting Co. His address is Metaline, Wash.

Robert W. Berkhahn has been transferred by the American Smelting and Refining Co. from the El Paso ore testing laboratory to the Charcas unit in Mexico where he is the metallurgist.

R. E. Barthelemy, consulting engineer of Hollywood, Fla., is in French

R. E. Barthelemy

Guiana where, under the program of technical assistance to foreign countries, he is organizing and supervising the rehabilitation of the largest gold mining project in that country. He expects to be in the field until spring and can be reached through his office at 1329 Polk St., Hollywood, Fla.

Gordon T. Brown

Gordon T. Brown is chief engineer of the Theodore A. Dodge Enterprises, 403 N. 3rd Ave., Tucson, Ariz. He was with the American Smelting and Refining Co.

R. D. Cramer recently joined the mining engineering staff of the Oliver Iron Mining Co., working at Virginia, Minn., on the Mesabi range.

W. H. H. Cranmer, president and general manager of the New Park Mining Co., and **Clark L. Wilson,** superintendent, received the bronze Oscar for the best 1948 Mining Company Annual Report as judged by the *Financial World.* They were given the award at the annual dinner at the Statler Hotel, New York City, on Oct. 31.

J. T. Crawford became vice-president of operations of the North Western-Hanna Fuel Co. on Sept. 1. Company operations include fourteen large coal docks on Lake Superior, Lake Michigan, Sault Ste. Marie, and the Twin Cities, including their associated retail yards. These operations handle in excess of 4,000,000 tons annually.

Walter E. Duncan resigned from the Ozark-Mahoning Co. to become chemical engineer for the Natural Resources Research Institute, University of Wyoming, Laramie.

R. Tracy Eddinger is leader, chemical engineering group in the development department of the Pittsburgh Consolidation Coal Co., Library, Pa.

Thorold F. Field, consulting mining engineer of Duluth, has been in England and on Oct. 20 went to Africa to visit mining areas there. **George G. Gallagher** has been made assistant manager of the raw materials operations office of the U.S. Atomic Energy Commission, replacing **Jesse C. Johnson,** who recently was appointed manager. He will have direct supervision of the domestic uranium program of the AEC.

Murray C. Godbe, III, has gone to San Juancito, Honduras, as a geologist and mining engineer for the New York & Honduras Rosario Mining Co. at their Rosario property.

Robert Y. Grant, chief, mining and geology division, NRS, general headquarters, Supreme Commander for the Allied Powers, has returned to Japan after a visit to the States to discuss mining, metallurgical, geological, and research problems with representatives of the Bureau of Mines, USGS, research organizations and mining companies.

Edward J. Harvey is living in Henderson, Ky., where he is working for the U. S. Geological Survey.

John A. Heyde graduated in mining engineering from the University of Arizona last January and went to work as a junior engineer for the Phelps Dodge Co. Morenci branch.

James Hopkins is now employed as a mining engineer for the Strategic and Critical Materials Division, Bureau of Federal Supply in San Francisco. His home address is 514 Masonic Ave., Albany, Calif.

Robert C. Horton is working for the USGS as a geologist assistant. Mail addressed to 643 Chestnut St., Apt. 5, Reno, Nev., reaches him.

J. K. Gustafson is leaving his post as director of the raw materials division of the Atomic Energy Commission to become consulting geologist for the M. A. Hanna Co. He will make his headquarters in Cleveland. **Jesse C. Johnson** will succeed him in the AEC post.

J. M. Currie

J. M. Currie, after completing a three year contract last August as mill superintendent for the South American Development Co. in Ecuador, enrolled in the graduate school at MIT as a candidate for a mineral engineer degree in the department of metallurgy.

Harold B. Houston, an August graduate of Oklahoma A&M, can be reached at 5363 N. Latrobe Ave., Chicago 30. He's hunting for appropriate work in exploratory or productive mineral geology.

Robert W. Hoyer transferred in October from Battle Mountain, Nev., to the Natoma, Calif., office of the Natomas Co., the main office of the gold dredging department.

W. D. McMillan is now supervising engineer of the Silver City, N. Mex., field office of the Bureau of Mines, having been transferred from Austin, Texas. With the Bureau since 1940, after 26 years with private companies, he has examined mines and been in charge of projects in various Midwestern and Western states.

W. D. McMillan

Ricardo A. Jimenez received his B.S. in mining engineering from Lehigh in October and is working for the Inland Steel Co., Wheelwright, Ky., as an engineer.

Vern L. Kegler has been enjoying a long deferred vacation since leaving the Texas mining and smelting division of the National Lead Co., Laredo, Texas. He was formerly president of the Texas Mining & Smelting Co., antimony producers, until the operations were acquired by National Lead in 1946. He remained with National Lead as manager of the Laredo division and later as consultant. His present address is 2007 Galveston St., Laredo.

John Lamprecht has joined the mining engineering department of the Oliver Iron Mining Co. on the Mesabi range. He is located at Virginia, Minn.

R. K. Matheson is night superintendent for the U. S. Potash Co. at Carlsbad, N. Mex.

James P. Margeson, Jr., executive vice-president of the International Minerals & Chemical Corp., has been elected a director of the Corporation. He has been with them for ten years.

John J. Mulligan, a Missouri School of Mines man, is working for the Bureau of Mines at Juneau, Alaska.

Edward G. Oman at the present time is a rock bit representative for the Timken Roller Bearing Co. His address is N. 4703 Stone St., Spokane 14, Wash.

William R. Paine received his M.S. degree in geology from the University of Wyoming and now is assistant professor of geology at Monmouth College, Monmouth, Ill.

Ben H. Parker, Jr., after graduating from the Colorado School of Mines last June, went to work as a junior geologist with the Rocky Mountain division of the Union Oil Co. at Laramie, Wyo.

John A. Patterson has gone to Georgetown, British Guiana, as a mining engineer with the Diamonds and Metals Exploration Co.

M. F. Quiroga, following the end of mining operations of the Moctezuma Copper Co. at Pilares and Nacozari, Mexico, moved to Hermosillo, Son., Mexico, to continue in consulting work and mine operation.

J. M. Powelson

J. M. Powelson has severed his connection with the exploration division of the Consolidated Mining and Smelting Co. of Canada. His address is Box 356, Haileybury, Ont. He is available on a consulting basis as a mining geologist for examinations, evaluations, and supervision of exploration schedules.

E. R. Ramsey, president of The Dorr Co., returned in November from a six weeks' trip to Europe during which he visited company associated organizations in London, Paris, Brussels, and Amsterdam, and made a tour of various installations of his company in Great Britain and the Continent. He was accompanied by **Arthur Terry, Jr.**, vice-president in charge of European administration.

Robert T. Reeder is an engineer with the U. S. Potash Co., Carlsbad, N. Mex. He graduated from the

Colorado School of Mines last May.

John Smith recently accepted a post as Engineer in the engineering department of the Asbestos Corp., Thetford Mines, Que.

D. P. Smith has joined the Oliver Iron Mining Co. at Hibbing as a trainee in the department of mining engineering.

Carl T. Ulrich, vice-president and treasurer of the Kennecott Copper Corp. and president of the Kennecott Sales Corp., has been made chief executive officer of Kennecott.

Alexander N. Winchell has accepted an appointment as visiting professor of geology at Columbia for the present school year.

Fremont E. Wood has resigned as mechanical-electrical superintendent for the Mexican mining department of AS&R to accept a mechanical-electrical engineering post with the Cyprus Mines Corp. on the Island of Cyprus.

Mr. & Mrs. Jack Torrington

Jack Torrington and his wife were in Wiarton, Ont., this fall, returning briefly from Malaya where he "has been collecting tin when not fighting bandits."

Frank G. Woodruff has succeeded the late Harry Davenport as general superintendent of the Mount Hope iron mining division of the Warren Foundry & Pipe Corp., Wharton, N.J.

Felix E. Wormser takes office as president of the Mining and Metallurgical Society of America on Jan. 10. **James L. Head** is vice-president of the Society.

Howard I. Young, president of the American Zinc, Lead and Smelting Co., was reelected president of the American Mining Congress in December, even though in the December issue of ME gave the presidency to S. A. Easton. We apologize for the error; it was rather a large one since this is Mr. Young's seventeenth year as president of the AMC.

COMING MEETINGS

JANUARY

2 **Boston Section, AIME.**
4 **Chicago Section, AIME. T. B. Counselman on Fluidization of Solids in Noncatalytic Operations.**
6 **Columbia Section, AIME.**
9 **Chicago Section, Open Hearth Committee, Iron and Steel Division, Chicago.**
10 **Delta Section, AIME. Water injection.**
10 **East Texas Section, AIME.**
10 Society for Applied Spectroscopy, New York.
11 **El Paso Metals Section, AIME.**
11 **San Francisco Section, AIME.**
11 **Southwestern New Mexico Section, AIME.**
11-13 Society of Plastics Engineers, Cleveland.
13 **Rio de Janeiro Section, AIME.**
16 **Detroit Section, AIME.**
16 **Minnesota Section, AIME. Annual Meeting, Hotel Duluth, Duluth, Minn. Mining symposium conducted by the Center of Continuation Study of the Univ. of Minn. follows annual meeting on Jan. 17 & 18.**
16-19 Plant Maintenance Show. 4-day exposition and conference, Auditorium, Cleveland.
17 **Gulf Coast Section, AIME.**
17 **Washington, D. C., Section, AIME.**
18 **Southwest Texas Section, AIME.**
18-20 ASCE, annual meeting, New York.
18 **Carlsbad Potash Section, AIME.**
19 **Ohio Valley Section, AIME. President's night.**
19 **Utah Section, AIME.**
20 **Oregon Section, AIME.**
24 **Montana Section, AIME.**
30 **Alaska Section, AIME.**
30-Feb. 3 AIEE, winter meeting, Hotel Statler, New York.

FEBRUARY

1 **Chicago Section, AIME. H. W. Johnson and C. D. King on prospective developments in steelmaking.**
2-4 Colorado Mining Association, Shirley-Savoy Hotel, Denver.
3 **Eastern Section, Open Hearth Committee, Iron and Steel Division, Warwick Hotel, Philadelphia.**
3 **Columbia Section, AIME.**
6 **Boston Section, AIME.**
8 **El Paso Metals Section, AIME.**
8 **San Francisco Section, AIME.**
10 **Rio de Janeiro Section, AIME.**
10 **Southwestern Section, Open Hearth Committee, Iron and Steel Division, all-day meeting, Lenox Hotel, St. Louis, Mo.**
12-16 **Annual Meeting, AIME, Statler Hotel, New York City.**
14 **Delta Section, AIME.**
14 **East Texas Section, AIME.**
15 **Southwest Texas Section, AIME.**
16 **Carlsbad Potash Section, AIME.**
16 **Utah Section, AIME.**
20-24 ASTM, Shoreham, Washington, D. C.
27-Mar. 2 ASTM, William Penn Hotel, Pittsburgh.

MARCH

8-10 API, Adolphus Hotel, Dallas.
29-31 API, Skirvin Hotel, Oklahoma City, Okla.

APRIL

4-7 Nat'l. Assn. of Corrosion Engineers, St. Louis.
10-12 **Open Hearth Conference, and Blast Furnace, Coke Oven and Raw Materials Conference, Netherland Plaza Hotel Cincinnati.**
19-21 ASCE, spring meeting, Los Angeles.
23-26 American Ceramic Society, annual meeting, New York.
24-26 AMC Coal Convention, Netherland Plaza Hotel, Cincinnati.
25-26 Annual Metal Powder Show, Book-Cadillac Hotel, Detroit.

JUNE

24-30 First international conference on coal preparation under direction of Charbonnage du France.

JULY

3-8 Second Conference on Oil Shale and Cannel Coal, Glasgow.
10-15 World Power Conference, London.

AUGUST

28-31 American Mining Congress, metal mining convention and exposition, Fair Grounds, Salt Lake City.

OCTOBER

4-6 **Petroleum Branch, AIME, New Orleans.**
9-13 **Washington, D. C., Section & Mineral Economics Division, AIME, joint meeting, Shoreham, Washington.**
10 **Mineral Economics Division, AIME, fall meeting, Shoreham Hotel, Washington, D. C.**
13 **Southwestern Section, Open Hearth Committee, Iron and Steel Division, all-day meeting, Rice Hotel, Houston.**
20 **Eastern Section, Open Hearth Committee, Iron and Steel Division, annual all-day fall meeting, Warwick Hotel, Philadelphia.**
23-27 National Metal Congress, Chicago.
23-25 **Institute of Metals Division, AIME, fall meeting, Hotel Sheraton, Chicago.**

DECEMBER

7-9 **Electric Furnace Steel Conference, Iron and Steel Division, Hotel William Penn, Pittsburgh.**

APRIL 1951

2-4 **Open Hearth and Blast Furnace, Coke Ovens and Raw Materials Conference, Iron and Steel Division, Statler Hotel, Cleveland.**

Obituaries—

Leopoldo Barcena y Diaz, founder of Cia. Auxiliar de Mineria y Metalurgia, Bilbao, Spain, died on Oct. 9, 1949. Mr. Barcena was considered

Leopoldo Barcena y Diaz

a pioneer in the flotation of minerals in Spain. He was born at Barcenaciones, Santander, in 1891 and studied at Escuela Especial de Ingenieros de Minas de Madrid. His first job as mining engineer was in the Reocin mine operated by Real Cia. Asturiana de Minas for whom he built a pilot plant and washer, modernizing and enlarging it in later years. He became subdirector of the Reocin mine in 1930 and director of the Santander department of the company in 1936, and was active in executive posts of several other concerns.

George Franklin Campbell (Member 1946), vice-president of operations of the Old Ben Coal Corp., and vice-president and general manager of the Raleigh Wyoming Mining Co., died on June 18, 1949. He was president of the Illinois Coal Operators Association for several years and in 1945 was president of the Illinois Mining Institute. Mr. Campbell was born in Coal City, Ill., in 1889, and graduated from Purdue. In 1913 he became foreman in charge of construction for the Ohio Valley Mining Co., remaining with the Company until 1917 when he joined Old Ben as general outside superintendent.

Walter Bannister Congdon (Member 1928), former director of the Calumet & Arizona Mining Co., died on Oct. 20, 1949, while visiting Westhome, ranch house for the Congdon Orchards, in Yakima valley, of which he was president. He was 64 years old. After graduating from Yale, he worked for the Oliver Iron Mining Co., joining Calumet & Arizona in 1910 as purchasing agent. He became a director of the company in 1917.

Nathan Bullock Chenault, Jr., (Member 1936), of Mt. Vernon, Ill., is dead. Born in Wichita Falls, Texas, in 1915, he received his B.S. in petroleum engineering from the University of Oklahoma in 1937. During summer vacations he was roughneck for Prince Bros. Drilling Co. and after graduation became petroleum engineer for the British American Oil Producing Co.

Walter Raleigh Cliffe (Member 1944), consulting engineer, Lime Industry Management and Engineering, of Hershey, Pa., was the victim of a fatal accident Sept. 22, 1949 on his farm near Annville, Pa. Mr. Cliffe was born in Philadelphia in 1895 and left the University of Pennsylvania at the beginning of World War I to serve in the French army. Upon his return to the States, he became associated with the Keystone State Construction Co., and later with the Warner Co. of Philadelphia, of which he became vice-president. In 1943, after working with the H.E. Millard Lime and Stone Co., he devoted his entire time to his consulting business, which under the name of L.I.M.E., was expanding rapidly. Mr. Cliffe and his growing organization have acted as consulting engineers for a number of pulp mills and cement plants as well as continuing an active interest in the lime industry.

Carter Stanard Cole (Member 1942), staff engineer for the American Society for Testing Materials, Philadelphia, died Nov. 17, 1949. He was 53 years old. Mr. Cole worked for the Pennsylvania Railroad from 1919 to 1928, during which time he invented an indicator for feed water pumps which was adopted as standard by the railroad. In 1928 he began his association with the Copper and Brass Research Association. He edited the Association's technical handbooks and was particularly active in the study of water corrosion.

William E. Brewster (Member 1933), who retired last January as manager of operations for the International Harvester Company's steel division, died on Dec. 18, 1949. An appreciation of him will appear in a forthcoming issue.

Thomas Arnold Dickson (Member 1941), president of the Colorado Iron Works Co., died in Denver on Oct. 19, 1949, at the age of 63. Ted Dickson was born in Leadville and his career, a brilliant one, was in the familiar American tradition of coming up the hard way without benefit of formal technical training. Unable to complete his education, he started as a smelter chemist's assistant, and at the age when many young men are starting their professional career, he was in charge of smelters in Mexico and Arizona. Later he branched into cyanide work on the Comstock

Thomas Arnold Dickson

Lode. Between employment on operating assignments he worked for Colorado Iron Works as a salesman of metallurgical equipment, laying the ground work of what was later to be his life work. In 1917 he returned to Colorado Iron Works as general manager and eventually acquired ownership of the company. His career as a machinery manufacturer is without parallel. Few men knew the smelting and milling business as well as Ted; he was responsible for the development and wide acceptance of the Akins classifier. His inventiveness is witnessed by the ownership of various patents relating to roasting and classification processes and he was always on the alert to improve his company's products.

Homer Morgan Faust (Member 1944), mining engineer with the New York Coal Co., Columbus, Ohio, died Sept. 19, 1949, of injuries sustained in a train-car accident. Born in 1899, he received an M.Sc. degree from Ohio State in 1924. He worked for the Ohio River Edison Co. for a few months and then became service engineer for the Consolidation Coal Co. He returned to Ohio State in 1929 as senior research engineer and assistant professor of mechanical engineering. In 1933 he joined New York Coal Sales as a research engineer. Mr. Faust was active in AIME affairs, serving as chairman of two committees in the Ohio Valley Section, and an active member on three other committees.

Walter John Felber (Member 1937), on the staff of the Inland Steel Co., died March 18, 1949. He was born at Milwaukee in 1915, received his B.S. degree from the University of Wisconsin in 1937, and went to work as sales apprentice for Inland Steel.

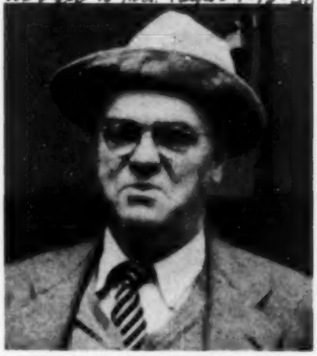
Solomon R. Guggenheim (Member 1923), 88-year-old mining magnate and last of the famous Guggenheim brothers, died Nov. 3 at his home on Long Island. Fourth of seven sons of a Philadelphia importer, Solomon was born when interest in the mineral resources of the West was on the rise. He gained mining know-how by investigation of prospective mining property purchases for his father, a cautious investor who had one of his sons look into a deal before its consummation. Solomon's first appraisal was a one-year stay at Leadville, watching operations of the A.Y. and the Minnie, as well as the Philadelphia smelter there. In 1889 he went to Mexico to take charge of the construction of the first lead-silver smelter; in 1891 he negotiated the purchase of a copper mine to add to the firm's holdings. Guggenheim Brothers' earnings from these, upon merging with AS&R in 1901, including a smelter in Pueblo and a refinery in Perth Amboy, totaled $4,500,000. William eventually withdrew from the firm, which had moved into finance and banking as well as mining, but six brothers carried it on as a tightly owned family corporation. AS&R acquired control of mining operations all over the world. Holdings of the Guggenheim Brothers were carried in individual Guggenheim names, with Solomon delving into Chilean nitrates while acquiring large Kennecott Copper holdings. In January 1940 he held 162,000 shares in Kennecott and this part of the family interests even through depression years had brought in a return up to $565,922 in one year.

One of Solomon's major contributions to the fraternal fortunes was that of weather-vane, predicting future courses from public utterances of politicos, election returns, and general trends.

In the business world the Guggenheim brothers were a unit; in the field of philanthropy each gave according to individual desires, but all were inconspicuous in doing it. Most of Solomon's many gifts were never known to the public; he gave munificently and quietly. Non-objective art interested him in later life, an interest aroused by so many people calling it bunk. He was one to investigate and form his own opinions. Results of investigation was a large collection of modern and abstract art.

William Walter Taylor (Member 1939), whose last job was with Stone & Webster Engineering Corp. for the Tennessee Gas Transmission Corp., died in his sleep Aug. 13, 1949. Varied engineering and

ret'd pix to Mrs. Taylor 1-12-50



William Walter Taylor

construction work for mining companies in the States, Canada, and Chile, preceded the post of construction superintendent for D. P. Robinson on sulphur and steam plants and a sugar refinery. From 1931 to 1937 he was superintendent of construction for M. W. Kellogg in charge of a variety of jobs and in 1938 he was in charge of the installation of equipment at the Irvin works of the U.S. Steel Corp. He worked for Ulen & Co. and for J. G. White and in 1943 was project manager on Plancor 880, a large 100 octane aviation gasoline refinery. A year later he was in Concepcion, Chile, constructing a large steel plant for Cia. de Acero del Pacifico.

Guy Carleton Jones (Member 1937), former resident director in South Africa of the Consolidated Gold Fields of South Africa, died in December 1948. He became associated with the firm in 1914 and in 1939 was elected to the board as resident director, filling the appointment with conspicuous energy and ability until his retirement due to ill health.

Thomas Knight Knox (Member 1926), former vice-president of the Republic Natural Gas Co., died March 7, 1949, ending an active and useful career as a geologist and petroleum engineer. Mr. Knox, who was born in Anniston, Ala., in 1896, had wide experience in the oil industry including two years as a drilling contractor and oil producer in Louisiana and Texas, four with Gas-Products Co., and nine as valuation and appraisal engineer with P. M. Biddison and Texla Royalty Co., Dallas. He became chief geologist of Republic Natural Gas when it was organized in 1935.

Archibald Little (Member 1901), formerly at C Mine, Belingwe, S. Rhodesia, died on June 24, 1948. When he joined the Institute he was director of gold mining companies in South Africa, capable in both mine and mill. He had developed and managed mines for several concerns.

John W. Mercer (Member 1897), mining engineer, well known in the States and South America, died Oct. 18, 1949 at the age of 85. He was director of the South American Mines Co. and vice-president of the Kelowna Exploration Co. of British Columbia. He had been an active operator of gold mines in Ecuador for 25 years.

Algernon S. Schafer (Member 1928), retired senior partner of the brokerage firm of Schafer Brothers and a member of former Governor Herbert H. Lehman's military staff, died Feb. 12, 1942. He had been appointed to the Office of Production Management in Washington, but a heart attack prevented his continuing in the post.

Proposed for Membership

Total AIME membership on Nov. 30, 1949, was 16,130; in addition 4658 Student Associates were enrolled.

ADMISSIONS COMMITTEE

James L. Head, Chairman; Albert J. Phillips, Vice-Chairman; George B. Corless, T. B. Counselman, Ivan A. Given, Robert L. Hallett, Richard D. Mollison, and John Sherman.

Institute members are urged to review this list as soon as the issue is received and immediately to wire the Secretary's Office, night message collect, if objection is offered to the admission of any applicant. Details of the objection should follow by air mail. The Institute desires to extend its privileges to every person to whom it can be of service but does not desire to admit persons unless they are qualified.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; AM, Associate Member; S, Student Associate.

Alabama

Birmingham—Kirkwood, Walter Robert. (M). Moore, Melvin Carl. (J).
Tarrant—Ruff, William B., Jr. (M).
Tuscaloosa—Dodd, Dorace Carr. (C/S—S-M).

Arizona

Ajo—Keener, William Hayes. (C/S—J-M).
Bisbee—Stuart, Herbert Zimmerly. (R, C/S—J-M).
Globe—Bamerio, Ralph Victor. (C/S—J-M).
Tucson—Fruitman, Frank W. (C/S—J-M).

Arkansas

El Dorado—Ragsdale, John G. (J).
Little Rock—Brown, Frederick Isaac, Jr. (C/S—S-J).

Malvern—Vincent, Kenneth Chapman. (C/S—J—M).

California

Avenal—Knowlton, Drexel Robert. (R, C/S—S-M).
Belmont—Wharton, Bruce Alan. (C/S—J-M).
Coalinga—Harris, Donald Fred. (J). Ustick, Ronald Errol. (J).
Desert Center—Wick, Dave Ervin. (C/S—S-J).
Folsom—Wells, John H. (C/S—J-M).
Glendale—Lockwood, R. Bruce. (M).
Grass Valley—Abell, Herbert Emery. (M). Courtney, Humphrey M. (AM).
Los Angeles—Kaplan, Maxwell Henry. (C/S—S-J). McMurry, Thomas Richard. (J). Sparkman, Richard Myron. (J). Townsend, Robert Dawson. (J). White, Robert Thompson. (M).
Menlo Park—Horn, Alvah Jordan. (C/S—J-M).
Modesto—Hockman, Albert Benjamin. (M).
Monterey — Thurston, George Henry. (C/S—J-AM).
Nevada City—Taylor, Thomas Hubbard. (C/S—J-M).
Oakland—Byrns, A. C. (M). Lundquist, Raynard Victor. (R,C/S—AM-M).
Pasadena—Howell, Baber Noyes. (R, C/S—J-M).
Riverdale—Graves, Charles Dennis. (R, C/S—S-M).
San Francisco—Crosby, James Winfield, III. (C/S—S-J). Hoskins, Charles Becker. (C/S—J-M).
Santa Barbara—Kamprath, Harry Erhard. (R—M).
Taft—Oliphant, John Joseph. (M).

Colorado

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